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Annual Meeting of the Southern California Academy of Sciences

California State University, Fullerton
June 1–2, 2007

FIRST CALL FOR SYMPOSIA AND PAPERS

The Southern California Academy of Sciences will hold its annual Meeting for 2007 on the campus of California State University, Fullerton Friday and Saturday June 1–2.

Presently the following symposia are in the planning stages. If you would like to organize a Symposia for this meeting, or have suggestions for a symposia topic, please contact Judy Lemus at jdlemus@usc.edu or Brad Blood at bblood@psomas.com. Organizers should have a list of participants and a plan for reaching the targeted audience.

Proposed Symposia for 2007

FRIDAY, JUNE 1.

Aquatic Invasive Species, organized by Sabrina Drill (sldrill@ucdavis.edu).

On-Going Paleoenvironmental Studies From Southern California and Surrounding Regions, organized by Dr. Matthew E. Kirby, California State University, Fullerton (mkirby@fullerton.edu)

Ecology, Oceanography and Human Impacts of the Southern California Bight, organized by Jim Allen (Jima@sccwrp.org).

Vulcanism and Plutonism in the Southwestern U.S. organized by Brandon Brown (bbrowne@exchange.fullerton.edu)

Prehistoric and Historic Impacts on the Environment, organized by Dr. Steven R. James (sjames@fullerton.edu) and Andrea P. Murray (amurray@fullerton.edu), California State University, Fullerton

Maintaining and Restoring Habitat Connectivity across the southern California Landscape, organized by Kristeen Penrod (kristeen@scwildlands.org)

Ecological, Environmental, and Evolutionary Parasitology, organized by Don Buth at UCLA (dbuth@ucla.edu) and Julianne Kalman (CSULB)

Biology of Rocky Reefs, organized by Bob Grove (grovers@sce.com) and Dan Pondella (pondella@oxy.edu)

SATURDAY, JUNE 2.

Avian Biology, organized by Kathy Keane (keanebio@yahoo.com)

Paleontology of Southern California, organized by Mark Roeder (maroeder1731@aol.com)

Diseases and other Maladies of So Cal Marine Mammals; organized by Dr. Richard H. Evans (snaver@cox.net)

Hydrology and Aquatic Life of the Santa Ana River, organized by Richard Zembel (RZembel@ocwd.com)

Contributed papers: Sessions of Contributed Papers will occur both days.

PLENARY SPEAKERS WILL BE:

Friday: Dr. Francisco Ayala, Donald Bren Professor of Biological Sciences at U.C. Irvine.

"Darwin and Intelligent Design". 7 p.m. followed by book signing

Saturday: Dr. Steven Murray, Dean, College of Natural Sciences and Mathematics and Professor of Biological Sciences, CSU Fullerton

"Science, Politics, the Public and Protecting California's Coastal Ecosystems" 11 a.m.

Contributed Papers and Posters: Both professionals and students are welcome to submit abstracts for a paper or poster in any area of science. Abstracts are required for all papers, as well as posters, and must be submitted in the format listed on the society webpage. Maximum poster size is 32 x 40 inches.

In addition **Junior Academy members** will submit papers for Saturday sessions.

Abstracts of presented papers and posters will be published as a supplement to the August issue of the Bulletin.

Student Awards: Students who elect to participate are eligible for best paper or poster awards in the following categories: ecology and evolution, molecular biology, genetics and physiology, and physical sciences. In addition the American Institute of Fishery Research Biologists will award best paper and poster in fisheries biology. A paper by any combination of student and professional co-authors will be considered eligible provided that it represents work done principally by student(s). In the case of an award to a co-authored paper, the monetary award and a one year student membership to the Academy will be made to the first author only.

For further information on posters, abstracts, registration and deadlines, see the Southern California Academy of Science web page at http://scas.jsd.claremont.edu/

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First Fossil Record of *Totoaba* Villamar 1980 (Teleostei: Sciaenidae) Based upon Early Miocene Otoliths from California with Comments on the Ontogeny of the Saccular Otolith

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Abstract.—A new species of the genus *Totoaba* (family Sciaenidae) based upon otoliths from the late early Miocene marine upper Olcese Sand, Kern County, southern San Joaquin Valley, California is described. This is the first fossil occurrence for the genus, and it is hypothesized that *Totoaba* evolved entirely in the eastern Pacific realm. Within the upper Olcese Sand, this species represents but one component of a complex sciaenid fauna, which could provide insight into the evolution and distribution of the family Sciaenidae. An ontogenetic series of this species is defined, and ontogenetic changes in its otoliths are discussed.

Totoaba Villamar 1980 is represented by a single extant species, *T. macdonaldi* (Gilbert 1890), and is the largest of about 270 extant sciaenid species (croakers and drums) with a length of over 200 cm (Chao 1995) and a maximum reported weight of over 100 kg (Barrera-Guevara 1990). Many aspects of the biology and ecology of this species are poorly known. This demersal species is endemic to the Gulf of California, Mexico; it once supported an important commercial and sport fishery, which was based on its annual spring breeding migration to the shallow, formerly brackish, waters of the Colorado River delta at the north end of the Gulf. *Totoaba macdonaldi* once ranged from the mouth of the Colorado River to Bahia Concepcion on the west coast of the Gulf of California and to the mouth of the El Fuerte River in the east (Berdegue 1955), but is now restricted to the northern Gulf. In 1976, as a result of overfishing and habitat alteration, this species was placed on the endangered list of the Convention on International Trade in Endangered Species (CITES) (Berdegue 1955; Flanagan and Hendrickson 1976; Cisneros-Mata et al. 1995). Recent studies support evidence of a small, but stable, population of *Totoaba* in the northern Gulf of California (Cisneros-Mata et al. 1995; Roman-Rodriguez and Hammann 1997).

Villamar (1980) established the genus *Totoaba* to separate *Cynoscion macdonaldi* Gilbert 1890 from *Cynoscion* Gill 1861. The new genus was based on swimbladder morphology, saccular otoliths, pores on the dentary, and submaxillar folds. He noted features of the swimbladder in *Totoaba* more closely resembled the Indo-West Pacific genus *Bahaba* Herre 1935 than *Cynoscion.* Schwarzhans (1993) in his treatise of the recent and fossil otolith of the Sciaenidae recognized 21 "groupings" according to their otolith morphology. He noted that the saccular otoliths of *Totoaba* have a combination of plesiomorphic characters similar to other sciaenid groups such as the *Sciaena, Pogonias,* or *Bahaba* groups and considered that within the *Cynoscion* Group, the otoliths were most similar to *Atractoscion* Gill 1862. Otoliths of *Atractoscion* differ mainly in the moderate to strongly developed postcentral umbo on the outer face, which is true for otoliths of *Bahaba.* Based on these similarities, Schwarzhans (1993) provisionally retained *Totoaba* within the *Cynoscion* Group but acknowledged that the swimmbladder pattern "points to radically different systematic position." A phylogenetic analysis for the Sciaenidae by Sasaki (1989) using morphological, osteological, and myological evidence placed *Bahaba* and *Totoaba* in the subfamily *incertae sedis.*

In the 1960's and early 1970's, the late John E. Fitch and field parties extensively bulk sampled matrix from numerous localities for fossil teleostean otoliths from the richly fossiliferous, shallow-marine Tertiary sediments of the southeastern San Joaquin Basin along the western flank of the Sierra Nevada east of Bakersfield, California. These sediments have yielded, in addition to otoliths, abundant marine invertebrates, locally rich concentrations of marine vertebrates, and very rare land mammal remains (e.g. Mitchell 1966; Addicott 1970a; Savage and Barnes 1972; Mitchell and Tedford 1973; Barnes 1976; Clarke and Fitch 1979; Barnes and Mitchell 1984). One area, Barker's Ranch, intensively sampled by Fitch in the fossiliferous upper Olcese Sand contains a diverse nearshore ichthyofauna dominated by numerous sciaenid otoliths. The sciaenids represent over 50% of the total number of otoliths and contain at least 12 sciaenid taxa that are recognized by the authors, including several forms now restricted to the Altantic and Indo-Pacific. This represents the largest sciaenid fauna from the west coast of North America.

Clarke and Fitch (1979:492) in a study of Cenozoic teuthoid (cephalopod) statoliths from North America, reported that a 1,800 kg sample from numerous sites in the "Barker's Ranch beds" produced more than 100,000 fish otoliths and several thousand teeth of sharks, skates, and rays, *Cetorhinus* sp. (basking shark) gill rakers, and hundreds of squid statoliths. The otolith assemblage consisted of more than 65 kinds of fish belonging to 30 or more families. Some of the forms mentioned include sciaenids (drums and croakers), pleuronectids and bothids (right- and left-eyed flatfishes), serranids (basses), atherinids (silversides), mugilids (mullets), gobiids (gobies), clupeids (herrings), and other nearshore forms. They also noted that deepwater forms (melamphaids (bigscale fishes), morids (morid cods) myctophids (lanternfishes), macrourids (rattails), etc.) are relatively rare. Unfortunately, Fitch never formally described the otoliths from the Barker's Ranch area before his untimely death on 30 September 1982. His entire collection of Recent and fossil otoliths, including notes, correspondence, and library, were donated to the Natural History Museum of Los Angeles County, Los Angeles, California (LACM) and are housed in the Department of Ichthyology. Examination of the Barker's Ranch collection by the authors as part of this study revealed a pre-catalogue inventory of approximately 21,271 otoliths, not the 100,000 reported in Clarke and Fitch (1979). Stringer (1998) noted a similar inconsistency in the number of otoliths reported by Clarke and Fitch (1979) from the Pliocene Bowden shell bed of Jamaica. These discrepancies are unexplained but are possibly overestimations by Fitch, and it is unlikely that there are missing otoliths.

Fish otoliths are the specialized hard parts of the actinopterygian and sarcopterygian acoustico-lateralis system, situated in the membranous labyrinths in the otic capsules of the neurocranium. Bony fishes (teleostean) have three otoliths (the saccular, utricular, and lagenar) in each of the two labyrinths. Saccular otoliths tend to be the largest of the otoliths and are the most widely used for species identification and evaluation of taxonomic relationships due to their size and morphological characteristics (Gaemers 1984; Nolf and Steurbaut 1989; Lombarte et al. 1991). In addition, fossil otolith assemblages consistently provide a more detailed and accurate account of Tertiary ichthyofaunas than the exclusive use of isolated skeletal components or articulated remains (Breard and Stringer 1995; Nolf 1995; Nolf and Stringer 2003). Fossil otoliths are found in a wide spectrum of sedimentary environments and are common fossils in many marine sediments. In contrast, the preservation of fish skeletons nearly always represents unusual environmental circumstances (Nolf 1985, 1995).

In this paper we report the first fossil record of the sciaenid genus *Totoaba* and describe a new species based upon saccular otoliths. An ontogenetic series of this new species is defined, and ontogenetic changes in sciaenid otoliths are discussed.

Locality and Geology

Type and referred specimens described in this paper were collected from the Barker's Ranch Locality, LACM locality 6602, which is located in the hilly region to the northeast of Bakersfield, Kern County, California (Fig. 1). Collections were made from near the top of the upper Olcese Sand (Clarke and Fitch 1979:492; Takeuchi and Huddleston 2006:85). The Olcese Sand, part of the Temblor Group, interfingers with the underlying Freeman Silt (early Miocene) and the overlying Round Mountain Silt (middle Miocene) and has been informally subdivided into three unconformity-bounded depositional sequences (lower, middle, and upper) based upon lithologic facies characteristics (Addicott 1970a). In the type area for this unit, Addicott (1970a) estimated that the Olcese Sand is 300–360 m thick. In outcrop, the lower Olcese Sand is composed of very fine-grained, silty marine sandstone with interbedded sandy and clayey siltstone. Although the Olcese Sand is predominantly a marine unit, the middle part of this unit is nonmarine with lenses of marine deposits and is distinguish by fine- to coarse-grained, often pumiceous, sandstone with occasional gravel lenses, strong cross bedding, and a bluish-grey color. The upper Olcese Sand, the most fossiliferous part of the unit, is a very fine- to fine-grained, marine sandstone, which grades into a sandy siltstone southwards toward the Kern River and into a siltstone westward in outcrop (Olson et al. 1986; Olson 1988, 1990). At the Barker's Ranch locality, the upper Olsece Sand is well exposed and is overlain by mottled siltstone of the lower Round Mountain Silt. It is stratigraphically 43.5 m thick and is composed of fine-grained marine sandstone to sandy siltstone, infrequently faintly cross-bedded with interbeds of transported shells (Olson et al. 1986). This is also the area of Addicott's (1956, 1970a) *Bucklarkia barkeriana* zone (Barker's Ranch Fauna) and contains at least 116 species of mollusks. This zone includes gastropod assemblages of outer shelf to slope species such as *Trophon kernensis* (Addicott 1970a). It is interpreted to represent shelf deposits below normal wave base with frequent storm-induced, wave-formed beds and concentrated shell lags based upon abundant mollusks and foraminifera (Addicott 1970a; Olson et al. 1986; Olson 1990).

There is some uncertainty surrounding the exact stratigraphic provenance of LACM locality 6602. Clarke and Fitch (1979:492) placed the locality in the "upper part of the Olcese Sand." However, Barnes and Mitchell (1984:17) referred

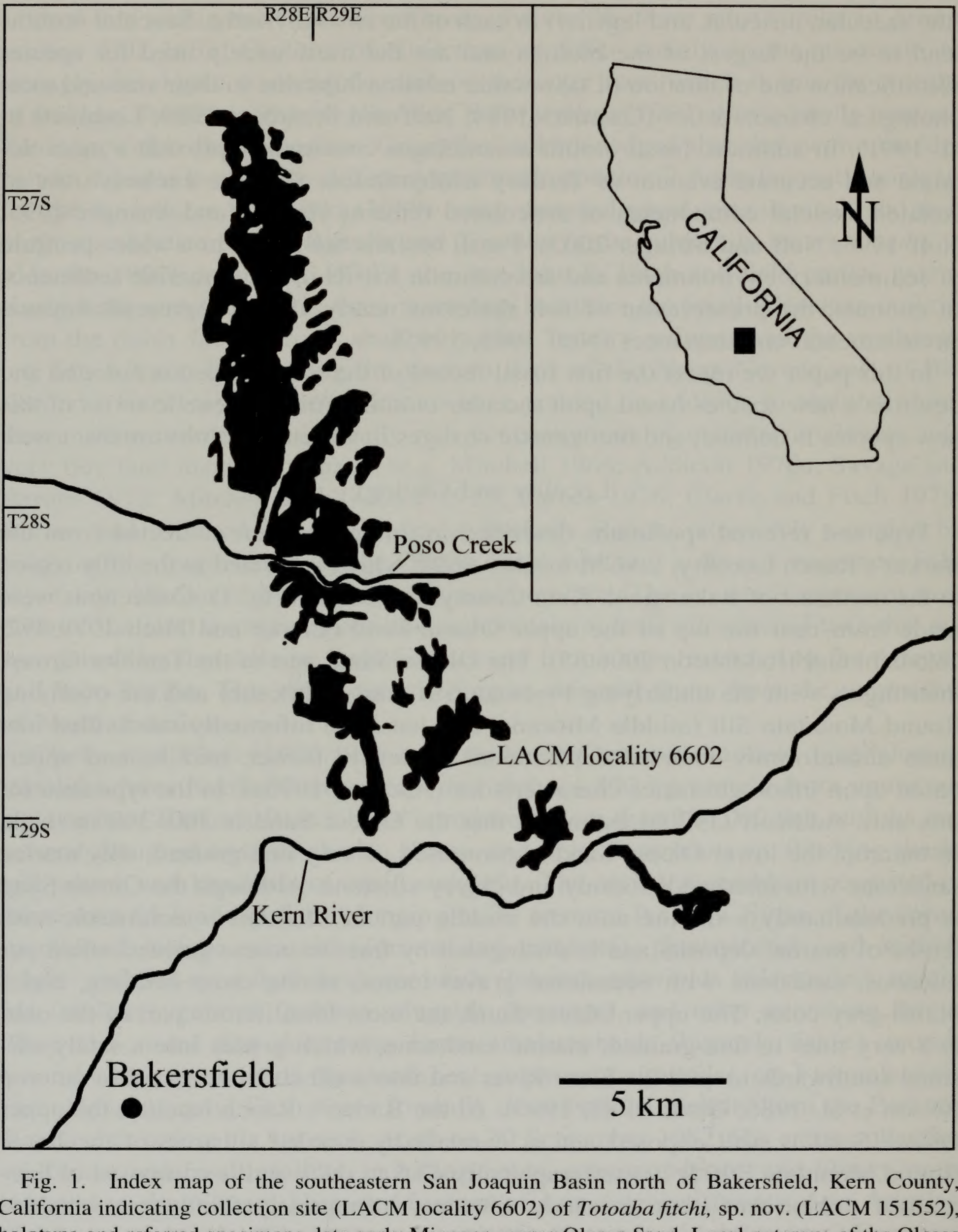

Fig. 1. Index map of the southeastern San Joaquin Basin north of Bakersfield, Kern County, California indicating collection site (LACM locality 6602) of *Totoaba fitchi*, sp. nov. (LACM 151552), holotype and referred specimens, late early Miocene, upper Olcese Sand. Local outcrops of the Olcese Sand indicated by shaded area. Modified after Olson (1990).

the locality to the "lower part of the Round Mountain Silt, below the Sharktooth Hill bone bed." Neither provided accurate stratigraphic nor locality data. Frequently, the delineation between the Olcese Sand and overlying Round Mountain Silt is indistinct due to a regressive event that separates the two units. A change in color and an increase in mica content in the Round Mountain Silt is the most noticeable character of the boundary (Olson 1990). In the Barker's Ranch area, the upper Olcese Sand is composed of fossiliferous very fine- to fine-grained, marine sandstone to sandy siltstone, with interbeds of transported shells, whereas the lowermost Round Mountain Silt is a mottled siltstone (Olson et al. 1986). The specimens described in this paper were found in a shell bed directly below a calcareously cemented sandstone that is approximately 14 m stratigraphically below a mottled siltstone. Thus, the type and referred specimens described in this paper are considered to be from sediments of the upper Olcese Sand.

A late early Miocene age for the upper Olcese Sand is based upon biostratigraphic correlation (Savage and Barnes 1972; Tedford et al. 1987:156; Tedford et al. 2004:fig. 6.2), benthic foraminiferal biostratigraphy (Olson 1990), and strontium isotope data (Olson 1988). Savage and Barnes (1972) correlated fragmentary land mammal remains (the Barker's Ranch Local Fauna) from the Barker's Ranch area with the late Hemingfordian North American Land Mammal Age (15.9–17.5 Ma). Strontium isotope results obtained from shell material near the top of the upper Olcese Sand at a nearby locality indicate an age of 16.7 Ma (Olson 1988). This date is compatible with benthic foraminiferal biostratigraphy, which suggests an upper Relizian age and is, therefore, assignable to the late early Miocene.

Material and Methods

Comparative specimens used in this study include saccular otoliths of *T. macdonaldi* and are from the collections of the Department of Ichthyology, LACM and Marine Vertebrate Collection, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, California (SIO). Additional comparative material was provided from a private collection.

The specimens described in this paper are housed in the collections of the Department of Vertebrate Paleontology, LACM. Uncatalogued and undescribed material from the Barker's Ranch locality is stored in the John E. Fitch Otolith Collection housed in the Department of Ichthyology, LACM. Bulk matrix samples were wet-screened and the remaining concentrated matrix was manually sorted under a dissecting microscope to remove identifiable otoliths, teeth, and bones. This method is fully described in Clarke and Fitch (1979:480–481). Specimens were photographed with a Nikon D70 digital camera.

Differences in proportional measurements were observed between smaller and larger otoliths of *Totoaba* and these differences were determined to be ontogenetic. In order to avoid confusion between ontogenetic and interspecific variation, for the purposes of our analysis, we define juvenile otoliths of *Totoaba* as those measuring less than 13 mm and adult otoliths of *Totoaba* measuring greater than 18mm in length. Morphological terms (Fig. 2) used in the general description follow Nolf (1985) and Schwarzhans (1993). A pseudo-ostial sulcus is defined as a sulcus possessing an ostium that is completely contained within the otolith and does not reach the anterior margin except in specimens displaying some degree of erosion. Linear measurements were made on an EPOI Shopscope optical micrometer. Measurements and proportional ratios of the otolith for the Sciaenidae follow Schwarzhans (1993), and are described below. Otolith measurements are shown on Fig. 3. Measurements used for proportional ratios on the inner face include the following: otolith length (L) is the greatest anterior to posterior length; otolith height (H) is the greatest dorsal to ventral height; ostium length (OL) is taken from the anterior edge of the ostium to the posterior most extension of the ostium, including the postostial lobe if present; ostium height (OH) is the greatest

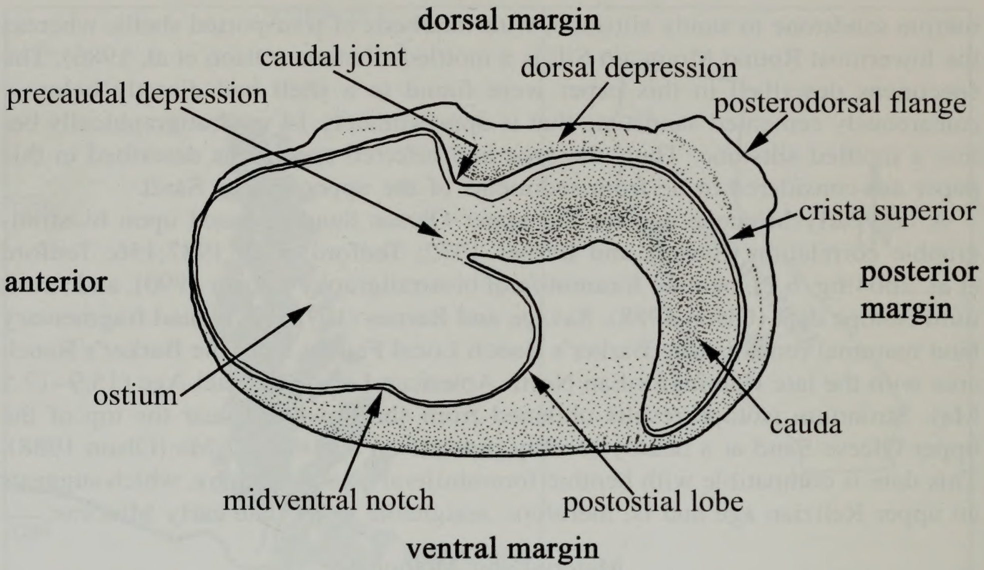

Fig. 2. Diagram of the inner face of a right saccular otolith of *Totoaba* illustrating its various diagnostic features. Modified after Schwarzhans (1993).

dorsal to ventral height of the ostium with the otolith in natural position; cauda length (CL) is measured from the dorsal edge of the cauda at the dorsal caudal joint and extending to the posterior most extension of the dorsal caudal margin; length of horizontal portion of the cauda (X) is measured from the caudal joint of the ventral caudal margin and extending to the posterior most extension of the ventral caudal margin; length of down turned portion of cauda (Y) is from the highest point of the ventral caudal margin to the posterior-most point of the cauda termination. Measurement used for proportional ratio from lateral view: otolith thickness (T), is the greatest inner face to outer face thickness taken in dorsal view.

Systematic Paleontology

Class Actinopterygii (sensu Nelson, 2006)
Division Teleostei (sensu Nelson, 2006)
Order Perciformes (sensu Johnson and Patterson, 1993)
Family Sciaenidae Cuvier, 1829
Genus *Totoaba* Villamar, 1980

Type-species.—*Cynoscion macdonaldi* Gilbert, 1890.

Generic diagnosis (emended from Schwarzhans 1993).—The saccular otolith is thick, massive, and slightly to moderately elongate with a rectangular to sub-rectangular outline, and all margins are nicely rounded. The dorsal margin is straight or slightly irregular. The anterior margin is blunted or gently curved with the ventral margin straight. The posterior margin is blunted, nearly vertical, and the posterodorsal margin has a short flange-like projection. The inner face of the otolith is moderately to strongly convex with a pseudo-ostial sulcus. The large spade-shaped ostium is flat and shallow, occupying the anterior half or more of the otolith. The postostial lobe is well developed and the ostium has a well-defined

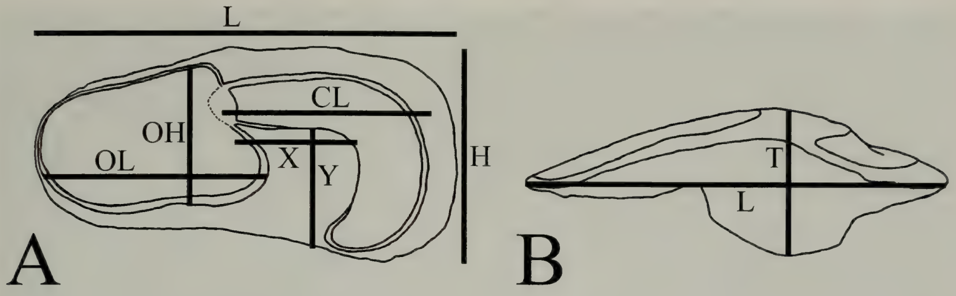

Fig. 3. Generalized sciaenid right saccular otolith with measurements used for proportional ratios. **A.** inner face; **B.** ventral view. **Abbreviations**: **CL**, cauda length; **H**, otolith height; **L**, otolith length; **OH**, ostium height; **OL**, ostium length; **T**, otolith thickness; **X:Y**, caudal curvature index (cci). Modified after Schwarzhans (1993).

midventral notch, with the dorsal margin generally straight. The narrow cauda arches dorsally from a precaudal depression, then is strongly curved, or bent ventrally. The anterior cauda is shorter or equal in length to the posterior cauda. The outer face of the otolith is moderately to strongly concave and sometimes has a bead-like postcentral umbo.

Totoaba fitchi, sp. nov.
Figures 4–5; Table 1

Holotype.—LACM 151552, left saccular otolith (Fig. 4).

Paratype.—LACM 151553, incomplete posterior right saccular otolith.

Referred specimens.—LACM 151554–151556, left saccular otoliths (Fig. 5); LACM 151557, incomplete posterior left saccular otolith (Fig. 5); LACM 151558, incomplete posterior right saccular otolith (Fig. 5).

Type locality.–LACM locality 6602, Barker's Ranch, Kern County, California; NW $^1/_4$ of Sec. 33, T. 28 S., R. 5 W., Rio Bravo Quadrangle, 7.5-minute Series, U.S.G.S., 1954.

Horizon.—upper Olcese Sand, late early Miocene, upper Relizian Benthic Foraminiferal Stage.

Etymology.—The holotype is named in honor of the late John E. Fitch, formally of the California Department of Fish and Game, who recovered the otoliths of *T. fitchi* and for his significant contributions to the study of fossil and Recent otoliths.

Diagnosis.—The saccular otolith of *T. fitchi* is distinguished from the extant *T. macdonaldi* by the following combination of characters: a thicker, less elongated, subrectangular shape; the outer face is without a definable umbo; the inner face is only slightly convex; the ostium is larger; and the anterior cauda is much shorter than the length of the posterior cauda (see caudal curvature index (cci) in Table 1).

Discussion.—The saccular otolith of *T. fitchi* shows a number of characters diagnostic of Sciaenidae including: a strongly homosulcoid sulcus, with both the rostrum and antirostrum absent; a broad, flat, shallow ostium with a distinct postostial lobe; and a narrow horizontal anterior cauda with a curved posterior cauda. Within the Sciaenidae, this species also shows several characters diagnostic of the genus *Totoaba* including: a large subrectangular saccular otolith with a broadly rounded anterior end and blunted posterior end; enlarged shallow ostium with a

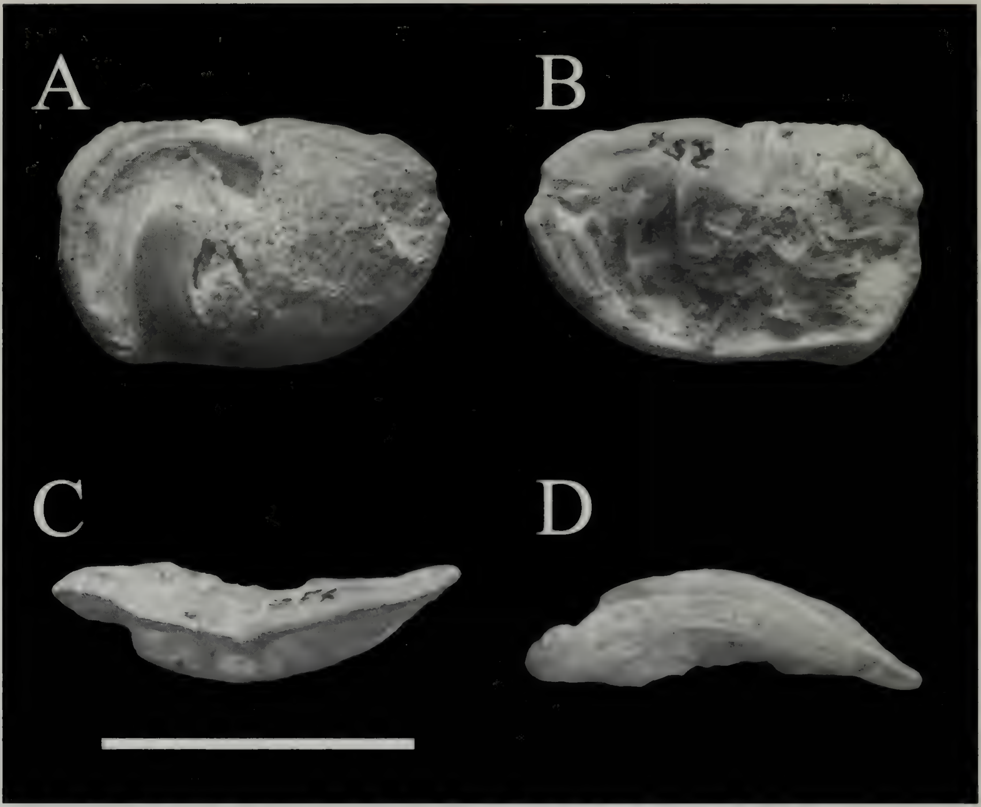

Fig. 4. *Totoaba fitchi,* sp. nov. (holotype; LACM 151552), left saccular otolith, late early Miocene, upper Olcese Sand, Kern County, California. **A.** inner face; **B.** outer face; **C.** dorsal view; **D.** ventral view. Scale bar equals 2 cm.

well-developed postostial lobe and a midventral notch; a short anterior cauda; and an equal or longer posterior cauda.

Description.—A slightly elongate left adult saccular otolith with a subrectangular outline, and all margins rounded. The total length is 25.5 mm, and the greatest height is 16.2 mm. Measurements and proportional ratios for the saccular otolith of *T. fitchi* are summarized in Table 1. The dorsal margin is nearly straight with a slight mediodorsal notch. The anterodorsal margin has a faint, low projection. The anterior margin is broadly rounded, and the ventral margin is nearly horizontal. The posterior margin is slightly blunted with a small dorsal flange present on the posterodorsal margin. The inner face is moderately convex with a pseudo-ostial sulcus. The ostium is large and spade-shaped, widening posteriorly, and occupying the anterior half of the otolith with a well-developed midventral notch. The postostial lobe is strongly developed, and the ostium is completely filled with a smooth, flat ostial colliculum. The cauda is moderately shallow and wide extending close to the posterior and posteroventral margins. The caudal joint is slightly constricted with the anterior cauda arching dorsally and then curving ventrally into a longer posterior cauda. The cauda tapers to a rounded point. The dorsal area is shallow, and the crista superior is well developed on the dorsal

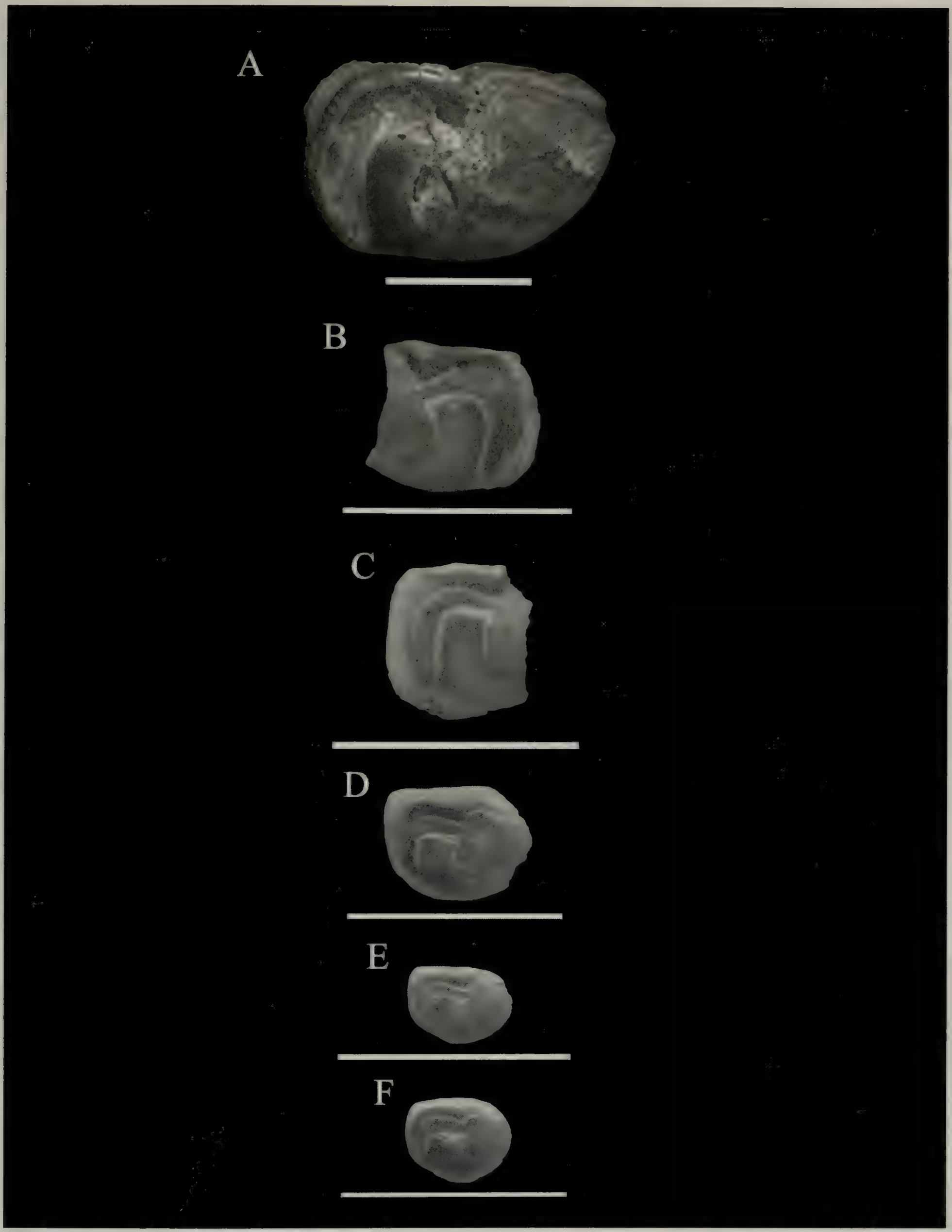

Fig. 5. Growth series of *Totoaba fitchi,* sp. nov. **A.** holotype, left saccular otolith, LACM 151552; **B.** incomplete posterior right saccular otolith, LACM 151558; **C.** incomplete posterior left saccular otolith, LACM 151557; **D.** left saccular otolith, LACM 151556; **E.** left saccular otolith, LACM 151555; **F.** left saccular otolith, LACM 151554. Scale bars equals 1 cm.

Table 1. Comparison of measurements and proportional ratios of the saccular otolith between species of *Totoaba*. **Abbreviations: l,** otolith length; **h,** otolith height; **t,** otolith thickness; **ol,** ostium length; **oh,** ostium height; **cl,** caudal length; **x,** horizontal portion of cauda; **y,** down turned portion of cauda; **x:y,** caudal curvature index (cci). See text and Fig. 3 for definition of abbreviations. Measurements are in mm.

	l	h	t	ol	oh	cl	x	y	l:h	h:t	cl:ol	ol:oh	cci
T. fitchi													
LACM 151552 (holotype)	25.5	16.2	7.5	17.2	13.6	8.9	5.5	9.5	1.57	2.16	0.52	1.26	0.58
LACM 151553 (paratype)	—	15.7	6.3	—	—	10.1	7.2	6.8	—	2.49	—	—	0.81
T. macdonaldi (adult)													
Mean	23.35	14.04	6.27	13.45	11.04	11.25	7.46	7.38	1.66	2.25	0.84	1.22	1.01
Standard Deviation	3.33	2.12	1.17	2.61	2.42	1.81	1.01	1.15	0.05	0.12	0.05	0.10	0.08
Coefficient of Variation	14.26	15.07	18.64	19.38	21.90	16.08	13.52	15.63	3.07	5.15	6.12	8.08	7.55
Maximum	29.8	18.5	8.6	18.3	16.2	15.0	9.4	9.9	1.74	2.41	0.93	1.43	1.12
Minimum	19.9	12.2	5.1	10.7	9.0	9.5	6.4	6.6	1.61	2.14	0.78	1.13	0.94
Number = 7													
T. macdonaldi (juvenile)													
Mean	11.05	6.70	3.45	5.65	4.50	5.17	3.60	3.02	1.65	1.96	0.92	1.26	1.20
Standard Deviation	1.18	0.74	0.45	0.79	0.67	0.72	0.40	0.49	0.01	0.30	0.12	0.15	0.10
Coefficient of Variation	10.70	11.03	13.07	14.05	14.85	13.88	11.11	16.05	0.52	15.57	13.46	12.32	8.35
Maximum	11.9	7.2	4.1	6.6	4.9	5.6	3.8	3.5	1.66	2.26	1.10	1.40	1.31
Minimum	9.3	5.6	3.1	4.9	3.5	4.1	3.0	2.4	1.64	1.64	0.83	1.06	1.08
Number = 4													

edge of the cauda margin. The outer face of the otolith is irregularly concave and thickens in the postcentral area but without a well-defined umbo.

Discussion and Conclusions

An important aspect in the study of fossil otoliths is the change that occurs in otolith morphology in relation to growth. The growth of saccular otoliths is proportional to the growth of the fish regardless of how the growth rate varies with time (Smale et al. 1995; Harvey et al. 2000). Otoliths at earlier juvenile stages generally exhibit a more pleisomorphic condition, while apomorphic characters evolve only in later developmental stages (Nolf 1985; Schwarzhans 1999). Sciaenid otoliths, in particular, display considerable ontogenetic change, and it is only in the late juvenile-early adult stage that all diagnostic features of the otolith become fully developed (Schwarzhans 1993).

Careful attention must be given to the morphological variations in otoliths caused by ontogeny; if unrecognized, these variations can lead to a number of taxonomic inaccuracies (Nolf 1985). The Sciaenidae possess particularly large saccular otoliths, sometimes exceeding 30 mm in length, and generally those less than 5–10 mm in length have not sufficiently developed the necessary diagnostic characters for accurate taxonomic assessment (Schwarzhans 1993). However, some groups of smaller sciaenids (e.g. *Isopisthus* Gill 1862, *Leiostomus* Lacepède 1802, *Seriphus* Ayres 1860, *Menticirrhus* Gill 1861, etc.) prove an exception to this rule, and all otoliths should be evaluated regardless of size. Only adult otoliths with fully developed characters should be used for type designation.

A series of six saccular otolilths of *T. fitchi* measuring 4.6mm–25.5mm in length (Fig. 5) allows us to propose an extended growth series for this species that reveals interesting allometric changes. These changes affect the major diagnostic characters of the otolith shape as well as sulcus morphology, which directly impact the reliability and level of identification possible. Without this reconstruction, several of the following otoliths would have remained unrecognized to genus or species. In the smallest otolith of *T. fitchi* (Fig. 5f), the characters are strongly pleisomorphic and possess only basic sciaenid features. The otolith is more ovate with a deep ventral margin. The dorsal margin is convex, and the posterodorsal margin is slightly angular with no posterodorsal projection. The ostium is small with no middorsal or midventral notch, and the postostial lobe is absent. The cauda is narrow with the anterior cauda slightly longer than the posterior cauda. As the otolith ontogenetically increases in size (Figs. 5d, e) it becomes more angular, while the dorsal margin is nearly horizontal. The ventral margin begins to shallow. The posterodorsal edge becomes angular, and the posterior margin is less curved with a dorsal and midventral notch on the ostium. The lengths of the anterior and posterior cauda are approximately equal. Otoliths at this stage have generic characters but are too generalized for species assignment. Even more mature, larger, otoliths (Figs. 5b, c) are subrectangular while the dorsal margin remains nearly flat and the posterior margin becomes more blunted. The posterodorsal margin is without a flange or projection, and the ostium has expanded to fill the anterior portion of the otolith. Otoliths of this size could only tentatively be assigned to species. In the fully adult stage (Fig. 5a; holotype), the otolith is subrectangular and slightly elongated with the posterior margin curved. The ostium has expanded to fill the anterior half or more of the otolith, and the dorsal margin of the ostium has become straight. The midventral notch has fully developed, with the postostial lobe present and the length of the anterior cauda is shorter than the posterior cauda. The width of the cauda has expanded, and a dorsal depression has developed. With the combination of these features, identification to species is possible.

The importance of constructing a growth series cannot be over emphasized. It provides a valuable tool in observing the development of diagnostic characters in the otolith. Caution must be exercised in selecting otoliths representing juvenile individuals in the sequence. Smaller otoliths are particularly sensitive to digestive erosion in the sulcus area and especially in the cauda. Nearly all isolated fossil otoliths have passed through the digestive system of predators prior to deposition (Nolf 1995) and are thus eroded to some degree.

Villamar (1980) hypothesized that the genus *Totoaba* is older than the formation of the Gulf of California, and *T. macdonaldi* evolved entirely in the Gulf. Current geological and geophysical studies of the complex origin and evolution of the Gulf of California indicate the opening of a Proto-gulf approximately 10–3.5 Ma (Karig and Jensky 1972; Helenes-Escamilla and Carreno 1999; Umhoefer et al. 2002), and its present configuration was established by the end of the Pliocene (Ledesma-Vazquez 2002). The occurrence of *T. fitchi* in the late early Miocene upper Olcese Sand supports Villamar's (1980) hypothesis and suggests that *Totoaba,* which is restricted to the northern Gulf of California today, appears to have evolved entirely in the eastern north Pacific Realm during, or prior to, the late early Miocene. The fossil record of the Sciaenidae is well documented in the Eocene to Oligocene of the Gulf Coast of North America (Koken 1888; Frizzell and Dante 1965; Breard and Stringer 1999; Nolf 2003; Nolf and Stringer 2003), and they do not appear along the Pacific Coast of North America until the early Miocene. Remarkably, sciaenids are totally absent from otolith rich Eocene deposits in southern California, and this absence has led us to hypothesize that the Sciaenidae initially invaded the eastern Pacific from the Gulf Coast region through the Panamanian Seaway sometime after the Eocene (Huddleston and Takeuchi 2006). Assuming that fossil *Totoaba* had similar ecological preferences as Recent *Totoaba,* the environment in the region of the Barker's Ranch area during the late early Miocene probably was a suitable habitat thoughout the year as suggested by the presence of both juvenile and adult *Totoaba* otoliths. Marine temperatures during the early and middle Miocene were warmer than off the Pacific coast of southern California today, and lower latitudinal gradients prevailed (Addicott 1970b; Olson 1987).

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Literature Cited

Addicott, W. O. 1956. Miocene stratigraphy northeast of Bakersfield, California. Ph.D. dissertation, Paleontology, University of California, Berkeley, California, 207 pp.

———. 1970a. Miocene gastropods and biostratigraphy of the Kern River area, California. U. S. Geol. Surv. Prof. Pap., 642:1–174.

———. 1970b. Tertiary paleoclimatic trends in the San Joaquin Basin, California. U. S. Geol. Surv. Prof. Pap., 644-D:1–19.

Ayres, W. O. 1860. [Description of fishes.] Proc. Calif. Acad. Sci. (Ser. 1), 77–81, 81–86.

Barnes, L. G. 1976. Outline of eastern North Pacific fossil cetacean assemblages. Syst. Zool., 25(4): 321–343.

———, and E. D. Mitchell. 1984. *Kentriodon obscurus* (Kellogg, 1931), a fossil dolphin (Mammalia: Kentriodontidae) from the Miocene Sharktooth Hill Bonebed in California. Contrib. Sci., Nat. Hist. Mus. Los Angeles Co., 353:1–23.

Barrera-Guevara, J. C. 1990. The conservation of *Totoaba macdonaldi* (Gilbert), (Pisces: Sciaenidae), in the Gulf of California, Mexico. J. Fish Biol., 37 (Suppl. A):201–202.

Berdegue, A. J. 1955. La pesquería de la totoaba (*Cynoscion macdonaldi* Gilbert) en San Felipe, Baja, California. Rev. Soc. Mex. Hist. Nat., 16(1–4):45–78.

Breard, S. Q., and G. L. Stringer. 1995. Paleoenvironment of a diverse marine vertebrate fauna from the Yazoo Clay (Late Eocene) at Copenhagen, Caldwell Parish, Louisiana. Gulf Coast Assoc. Geol. Soc., 45:77–85.

———. 1999. Integrated paleoecology and marine vertebrate fauna of the Stone City Formation (middle Eocene), Brazos River section, Texas. Trans. Gulf Coast Assoc. Geol. Soc., 49:132–142.

Chao, L. N. 1995. Sciaenidae. Pp. 1427–1518 *in* Guia FAO para la identificacion de especies para los fines de la pesca. (W. Fischer, F. Krupp, W. Schneider, C. Sommer, K. E. Carpenter, and V. Niem, eds.), Pacifico Centro-oriental. Vol. III. Vertebrados-Parte 2. FAO, Rome, 1813 pp.

Cisneros-Mata, M. A., G. Montemayor-Lopez, and M. J. Roman-Rodriguez. 1995. Life history and conservation of *Totoaba macdonaldi*. Conserv. Biol., 9(4):806–814.

Clarke, M. E., and J. E. Fitch. 1979. Statoliths of Cenozoic teuthoid cephalopods from North America. Palaeontology, 22:479–511.

Cuvier, G. L. C. F. D. 1829. Le Règne Animal, distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée, Nouvelle édition. Paris, 2:122–406.

Flanagan, C. A., and J. R. Hendrickson. 1976. Observation on the commercial fishery and reproductive biology of the totoaba *Cynocion macdonaldi*, in the northern Gulf of California. Fish. Bull., 74(3):531–544.

Frizzell, D., and J. Dante. 1965. Otoliths of some early Cenozoic fishes of the Gulf Coast. J. Paleontol., 39:687–718.

Gaemers, P. A. M. 1984. Taxonomic position of the Cichlidae (Pisces, Perciformes) as demonstrated by the morphology of their otoliths. Neth. J. Zool., 34:566–595.

Gilbert, C. H. 1890. A preliminary report on the fishes collected by the steamer Albatross on the Pacific coast of North America during the year 1889, with descriptions of twelve new genera and ninety-two new species. Proc. U. S. Natl. Mus., 49–126.

Gill, T. N. 1861. Revision of the genera of North American Sciaeninae. Proc. Acad. Nat. Sci. Phila., 13:79–89.

———. 1862. Note on the sciaenoids of California. Proc. Acad. Nat. Sci. Phila., 14:16–18.

Harvey, J. T., T. R. Loughlin, M. A. Perez, and D. S. Oxman. 2000. Relationship between fish size and otolith length for 63 species of fishes from the Eastern North Pacific Ocean. U. S. Dept. Commer., NOAA Tech. Rep. 150:1–36.

Helenes-Escamilla, J., and A. L. Carreno. 1999. Neogene sedimentary evolution of Baja California in relation to regional tectonics. J. So. Amer. Earth Sci., 12(6):589–605.

Herre, A. W. C. T. 1935. A new sciaenid from southeastern China. Lingnan Sci. J. Canton, 14(4): 603–604.

Huddleston, R. W., and G. T. Takeuchi. 2006. A new late Miocene species of sciaenid fish, based primarily on an *in situ* otolith from California. Bull. Southern California Acad. Sci., 105(1): 30–42.

Johnson, G. D., and C. Patterson. 1993. Percomorph phylogeny: a survey of the acanthomorphs and a new proposal. Pp. 554–626 *in* (G. D. Johnson and W. D. Anderson, Jr., eds.), Proceedings of the symposium on phylogeny of Percomorpha, June 15–17, held in Charleston, South Carolina at the 70th annual meeting of the American Society of Ichthyologists and Herpetologists, Bull. Marine Sci., 52:1–629.

Karig, D. E., and W. Jensky. 1972. The Protogulf of California. Earth. Planet. Sci. Lett., 17:169–174.

Koken, E. 1888. Neue untersuchungen an Tertiären fischotolithen. Z. deut. Geol. Ges., 40:274–305.

Lacepède, B. G. E. 1802. Histoire naturelle des poissons. Hist. Nat. Poiss., 4:1–728.

Ledesma-Vazquez, J. 2002. A gap in the Pliocene invasion of seawater to the Gulf of California. Rev. Mex. Cienc. Geol., 19(3):145–151.

Lombarte, A., J. Rucabado, J. Matallanas, and D. Lloris. 1991. Taxonomia numerica de Nototheniidae en base a la forma de los otolitos. Sci. Mar., 55(2):413–418.

Mitchell, E. D. 1966. The Miocene pinniped *Allodesmus*. Univ. Calif. Publ. Geol. Sci., 61:1–105.

———, and R. H. Tedford. 1973. The Enaliarctinae, a new group of extinct aquatic Carnivora and a consideration of the origin of the Otariidae. Bull. Am. Mus. Nat. Hist., 151(3):201–284.

Nelson, J. S. 2006. Fishes of the world, 4th ed. John Wiley and Sons, Inc., Hoboken, New Jersey, xix + 601 pp.

Nolf, D. 1985. Otolithi piscium. Pp. 1–145 *in* Handbook of Paleoichthyology Vol. 10. (H.-P. Schultze, ed.), Gustav Fischer Verlag, Stuttgart and New York.

———. 1995. Studies on fossil otoliths—the state of the art. Pp. 513–544 *in* Recent developments in fish otolith research. (D. H. Secor, J. M. Dean, and S. E. Campana, eds.), Univ. South Carolina Press, 735 pp.

———. 2003. Revision of the American otolith-based fish species described by Koken in 1888. Lou. Geol. Surv., 12:1–19.

———, and E. Steurbaut. 1989. Evidence from otoliths for establishing relationships within gadiforms. Pp. 89–111 *in* Papers on the systematics of gadiform fishes. (D. M. Cohen, ed.), Nat. Hist. Mus. Los Angeles Co., Sci. Ser. 32, ix + 262 pp.

———, and G. L. Stringer. 2003. Late Eocene (Priabonian) fish otoliths from the Yazoo Clay at Copenhagen, Louisiana. Lou. Geol. Surv., 13:1–23.

Olson, H. C. 1987. Biofacies zonation of Middle Miocene benthic foraminifera, southeastern San Joaquin Basin, California. AAPG Geol. Bull., 71(5):599.

———. 1988. Oligocene-middle Miocene depositional systems north of Bakersfield, California: eastern equivalents of the Temblor Formation. Pp. 189–205 *in* Studies of the Geology of the San Joaquin Basin. (S. A. Graham, ed.), Pac. Section SEPM 60, 351 pp.

———. 1990. Early and middle Miocene foraminiferal paleoenvironments, southeastern San Joaquin Basin, California. J. Foramin. Res., 20(4):289–311.

———, G. E. Miller, and J. A. Bartow. 1986. Stratigraphic, paleoenvironment and depositional setting of the Tertiary sediments, southeastern San Joaquin basin. 1986 Guidebook Pacific Section AAPG meeting, Bakersfield, California, 18–54.

Roman-Rodriguez, M. J., and M. G. Hammann. 1997. Age and growth of totoaba, *Totoaba macdonaldi* (Sciaenidae), in the upper Gulf of California. Fish. Bull., 95(3):620–628.

Sasaki, K. 1989. Phylogeny of the family Sciaenidae, with notes on its zoogeography (Teleostei, Perciformes). Mem. Fac. Fish. Hokkaido Univ., 36(1/2):1–137.

Savage, D. E., and L. G. Barnes. 1972. Miocene vertebrate geochronology of the west coast of North America. Pp. 124–145 *in* Proceedings of the Pacific Coast Miocene Biostratigraphic Symposium. (E. H. Stinemeyer, ed.), SEPM, 364 pp.

Schwarzhans, W. 1993. A comparative morphological treatise of recent and fossil otoliths of the family Sciaenidae (Perciformes), 1. *In* Piscium Catalogus, Otolithi Piscium. (F. Pfeil, ed.), Verlag Dr. Friedrich Pfeil, Munchen, 245 pp.

———. 1999. A comparative morphological treatise of recent and fossil otoliths of the order Pleuronectiformes, 2. *In* Piscium Catalogus, Part Otolithi Piscium. (F. Pfeil, ed.), Verlag Dr. Friedrich Pfeil, Munchen, 391 pp.

Smale, M. J., G. Watson, and T. Hecht. 1995. Otolith atlas of Southern African marine fishes. Ichthyol. Monogr., J. L. B. Smith Inst. Ichthyol., 1:1–253.

Stringer, G. L. 1998. Otolith-based fishes from the Bowden shell bed (Pliocene) of Jamaica: systematics and palaeoecology. Contr. Tert. Quatern. Geol., 35(1–4):147–160.

Takeuchi, G. T., and R. W. Huddleston. 2006. A Miocene chimaeroid fin spine from Kern County, California. Bull. Southern California Acad. Sci., 106(2):85–90.

Tedford, R. H., M. F. Skinner, R. W. Fields, J. M. Rensberger, D. P. Whistler, T. Galusha, B. E. Taylor, J. R. MacDonald, and S. D. Webb. 1987. Faunal succession and biochronology of the Arikareean through Hemphillian interval (late Oligocene through earliest Pliocene Epochs) in North America. Pp 153–210 *in* Cenozoic Mammal of North America. (M. O. Woodburne, ed.), University of California Press, Berkeley, Los Angeles, and London, xv + 336 pp.

Tedford, R. H., L. B. Albright, III, A. D. Barnosky, I. Ferrusquía-Villafranca, R. M. Hunt, Jr., J. E. Storer, C. C. Swisher, III, M. R. Voorhies, S. D. Webb, and D. P. Whistler. 2004. Mammalian biochronology of the Arikareean through Hemphillian interval (Late Oligocene through Early Pliocene Epochs). Pp. 169–231 *in* Late Cretaceous and Cenozoic Mammals of North America. (M. O. Woodburne, ed.), Columbia University Press, New York, xix + 391 pp.

Umhoefer, P. J., L. Mayer, and R. J. Dorsey. 2002. Evolution of the margin of the Gulf of California near Loreto, Baja California Peninsula, Mexico. Geol. Soc. Am. Bull., 114(7):849–868.

Villamar, A. 1980. *Totoaba,* un nuevo género de la familia Sciaenidae del Golfo de California, México (Pisces: Teleostei). An. Esc. Nac. Cienc. Boil. Méx., 23:129–133.

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Caudal Spine Shedding Periodicity and Site Fidelity of Round Stingrays, *Urobatis halleri* (Cooper), at Seal Beach, California: Implications for Stingray-related Injury Management

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Abstract.—Natural caudal spine replacement rates, population size and site fidelity of round stingrays, *Urobatis halleri* (Cooper), at Seal Beach, California were determined to evaluate the efficacy of clipping of caudal spines of stingrays to reduce injury to human beachgoers. Of the 2,183 stingrays caught, clipped, tagged, and released at Seal Beach, only 13 (0.06%) were recaptured over a three-year period, indicating a large, mobile population. Natural spine replacement occurred between August–October, when a majority of rays were found with two spines. Monthly catch rates of rays were variable, but positively correlated with the number of injuries reported by beachgoers. There was no significant reduction in stingray-related injuries to beach goers at Seal Beach over the period when stingray caudal spine clipping was conducted.

Several families of rays (Chondrichthyes: Myliobatiformes) are equipped with one or more venomous caudal spines located along the dorsal edge of the tail. These spines are used in defense against predators and can also inflict painful and potentially dangerous wounds to humans who unwittingly step upon them (Kizer 1990; Ebert 2003; Johansson et al. 2004). In coastal areas where stingrays are abundant, stingray-related injuries are increasing as humans increasingly use the nearshore marine environment. This is particularly evident in southern California, where large numbers of stingray-related injuries are attributed to the round stingray, *Urobatis halleri* (Cooper), a common ray along nearshore sandy beaches and bays (Russel 1953; Babel 1967; Allen et al. 2002; Ebert 2003; Hoisington and Lowe 2005).

Round stingrays are particularly abundant at Seal Beach, California, a relatively small (1.6 km long), popular urban beach where 200–300 round stingray-related injuries are reported annually to lifeguards (Capt. R. Pounds, Seal Beach Lifeguards, pers. comm.). Most of these injuries are concentrated in the northernmost

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500-m portion of Seal Beach, where several electricity-generating stations along the lower San Gabriel River discharge warm seawater effluent. Large numbers of round stingrays are known to aggregate at Seal Beach due to this warmer water (Babel 1967; Hoisington and Lowe 2005; Vaudo and Lowe 2006). The large number of stingray-related injuries and resulting negative economic impacts at Seal Beach have led local officials to seek methods to control the stingray population. However, previous population-level control measures at Seal Beach, such as culling and ray-fishing derbies, were deemed ecologically unsound and met with little success in reducing human injury events (Capts. S. Cushman & R. Pounds, Seal Beach Lifeguards, pers. comm.).

One method used to reduce stingray-related injuries is clipping of the caudal spine, a method applied by public aquaria to allow the public to handle live stingrays without being injured. Because the caudal spine is a modified dermal denticle, lacking innervation, the spine can be easily clipped without causing pain or injury to the ray (Johansson et al. 2004). A large-scale spine-clipping program may have the potential to reduce injuries at public beaches; however, this approach has not been tested in the field. To test the efficacy of large-scale spine-clipping programs in reducing the incidence of stingray-related injuries, a systematic caudal spine-clipping program was initiated at Seal Beach.

The effectiveness of such a program, however, is dependent upon the natural rate of caudal spine replacement, which has been shown to be a periodic phenomenon in several species of stingrays (Teaf and Lewis 1987; Thorson et al. 1988; Amesbury and Snelson 1997), and the feasibility of clipping the spines of a large percentage of the population. Therefore, the goals of this study were to: 1) measure spine replacement rate and periodicity for the population of round stingray at Seal Beach, 2) estimate monthly ray abundance using catch per unit effort at a single location, and 3) evaluate changes in the number of stingray-related injury rates over the 2.5-year duration of the spine-clipping program.

Methods

Field Collection

Round stingrays (*Urobatis halleri*) were sampled monthly from inshore waters along Seal Beach, California (33° 44.3′ N, 118° 06.5′ W) from 7 April 2000 to 13 December 2002 (Fig. 1). Collections were made using a 100 m long × 4.0 m deep beach seine with 2.0 cm mesh, a central catch bag, and 100 m long towlines at each end. A personal watercraft (jet ski) was used to pull the seine parallel to shore at a distance of approximately 50 m and the free towline was then brought to shore approximately 50 m southeast of the deployment point and both ends were pulled evenly onto shore by hand until the seine was completely out of the water. All round stingrays caught during seines were placed into holding pools for subsequent measurements and tagging, after which the rays were immediately released at the site of capture. One to three tows of the beach seine were conducted on each seine date, depending on the number of rays captured.

Stingray Measurements

The sex, disc width (W_D; to the nearest mm), number of caudal spines, and length of each spine (to the nearest mm) was determined for each ray. Based on observations of captive rays, it was determined that the most dorsal spine was

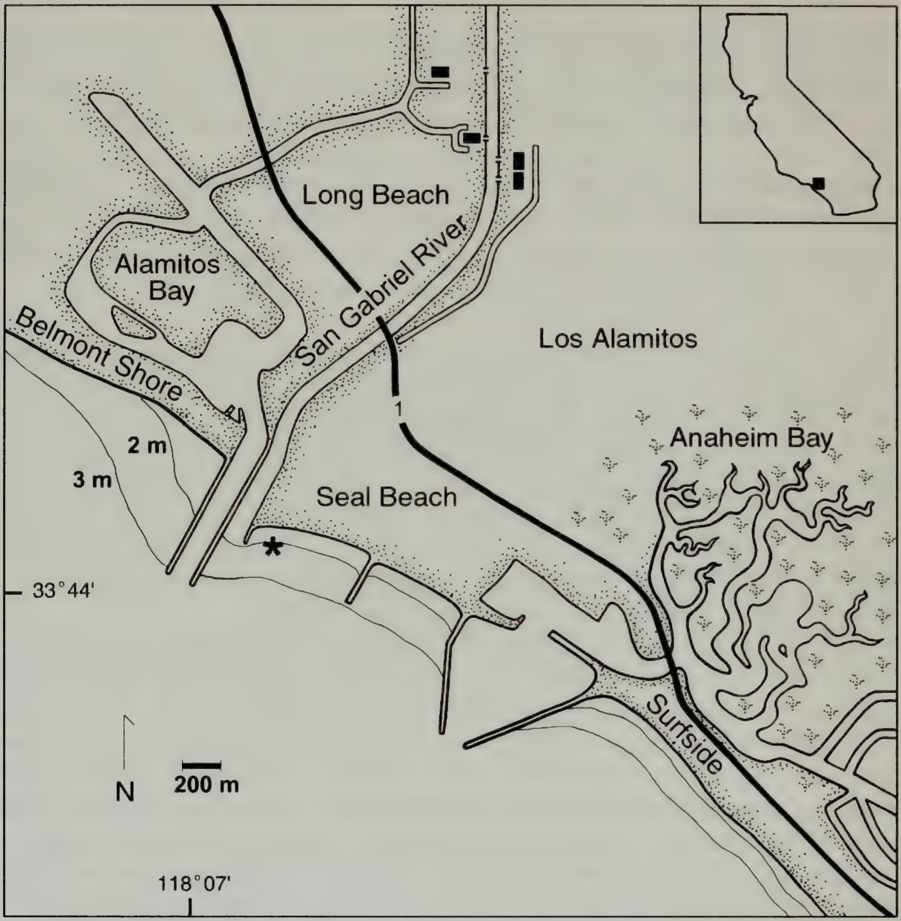

Fig. 1. Map of the Seal Beach, California study site. Asterisk indicates location of all beach seines conducted during this study. The black square in the inset shows the location of the Seal Beach area relative to California.

the primary (older spine), while secondary (replacement) spines erupted below the primary spine. Primary and secondary spine lengths were measured from the subcutaneous base of the spine shaft to its posterior point with calipers (accuracy ± 0.5 mm)(Johansson et al. 2004). After measurement, the erupted portions of all spines were clipped within 2–3 mm of the subcutaneous base using nail clippers. The relative growth rate of the secondary spine was determined using the ratio of secondary to primary spine length, and quantified using a linear regression. Analysis of covariance (ANCOVA) was used to test for a difference in caudal spine growth rates between field sampling years.

Tagging

All round stingray caught were tagged so we could track spine regeneration rates and spine growth from recaptured individuals in the field. From 7 April 2000 to 10 July 2002 all rays with a $W_D \geq 120$ mm, were fitted with a Peterson disc tag. Smaller rays (W_D 120–160 mm) were tagged in the pectoral fin, while larger rays ($W_D > 160$ mm) were tagged in the pelvic fin. Each tag carried a unique identification number and a contact phone number. These tags consisted of two 1.3 cm diameter × 1 mm thick plastic discs and a nickel pin. Tags were attached by placing a blank disc on the blunt end of the pin, pushing the pin through the fin of the ray, then placing the numbered disc on the pin, effectively sandwiching the fin between the discs. The pin was then folded down to hold the discs in place and any extra pin material was removed. Any subsequently recaptured rays were re-measured and released. To estimate tag retention, ten rays held in large tanks in the laboratory were fitted with Peterson disc tags using the same procedures described for field tagging. Growth rates of laboratory rays and the degree of fouling on the tag was assessed monthly for up to one year. Population estimates could not be made from tag-recapture data due to our failure to meet the assumptions of the Jolly-Seber open population model (Jolly 1965).

Injury Data and Catch per Unit Effort (CPUE)

Stingray-related injuries were tallied from Seal Beach Lifeguard injury reports from 1999 to 2002.. Injuries were grouped by month and year and analyzed using a two-way ANOVA to examine temporal trends in injury frequency in relation to spine-clipping. Estimates of ray abundance were based on CPUE derived monthly from beach seines. Additionally, CPUE was analyzed by linear regression to examine the relationship between CPUE and number of injuries per month, and by ANOVA to examine temporal trends in catch rate.

Results

Spine Replacement

Spine-shedding and replacement exhibited a distinct seasonal cycle. Throughout most of the year, the majority of rays sampled at Seal Beach had only one (primary) spine. However, small secondary spines were first noted in many rays beginning in July (Fig. 2). The percentage of rays with secondary spines increased steadily and reached peak numbers in September and October. Thereafter, the percentage of rays with two spines decreased rapidly as primary spines fell off and were replaced. By December, almost no rays were caught that had two spines (Fig. 2).

During the spine replacement period (summer and fall), the ratio of secondary spine length to primary spine length increased significantly over time (linear regression, 2000: $df = 1{,}72$, $p < 0.001$; 2001: $df = 1{,}178$, $p < 0.001$; 2002: $df = 1{,}435$, $p < 0.001$) (Fig. 3). Primary spines were shed and replaced by secondary spines as this ratio approached 0.8 to 1.0. In some cases, the secondary spine was larger than the primary spine (Fig. 3). Although secondary spine growth rate was somewhat variable between years, there was no significant difference in the rate of growth of the secondary spine among the three sampling years (ANCOVA: $df = 2{,}685$, $p = 0.11$) and no difference in the growth periodicity ($df = 2{,}685$, $p = 0.08$).

Tag and Recapture

We tagged 2,183 juvenile and adult round stingrays at Seal Beach, California and recaptured 13 (0.6%) during the course of the study. All rays were recaptured

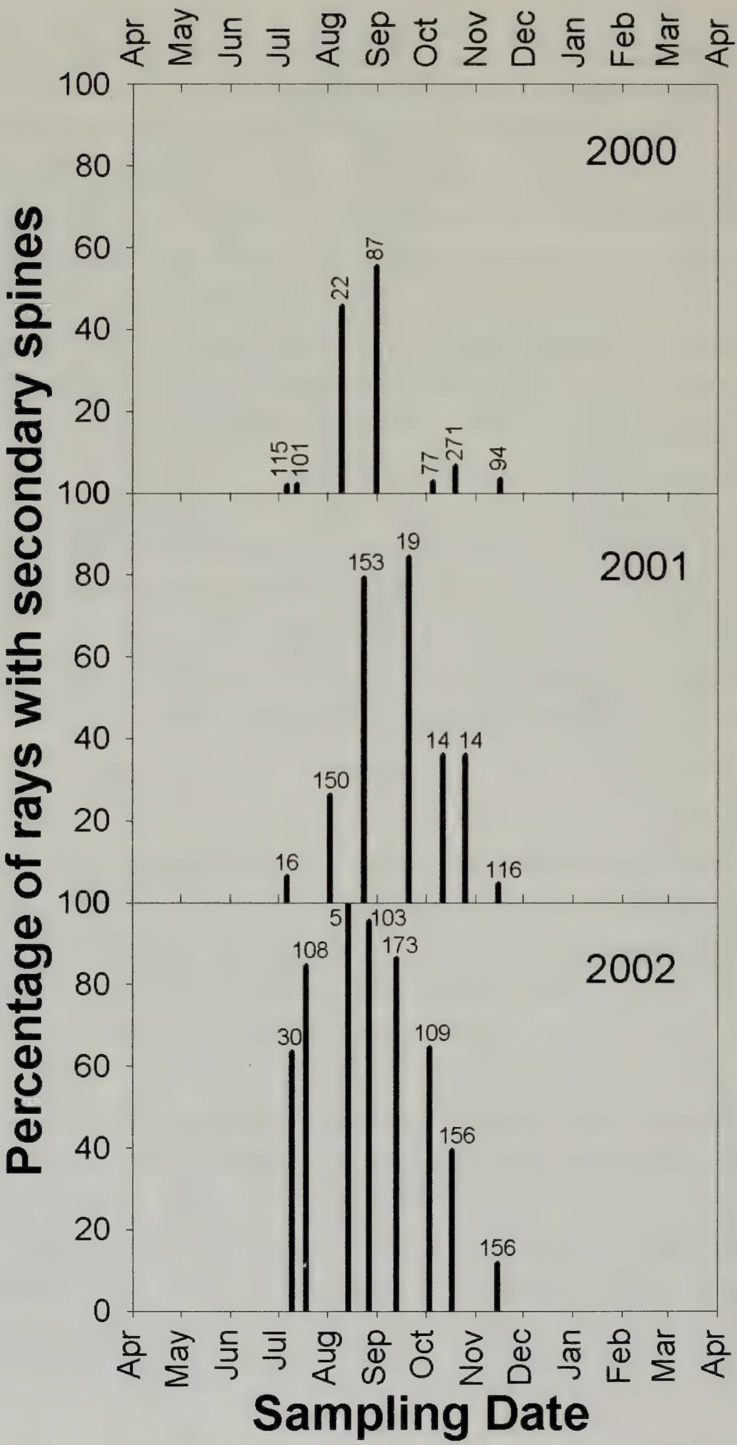

Fig. 2. Percentage of rays with secondary spines during discrete sampling dates, 2000 through 2002. Numbers above each bar represent the sample size on that date. No rays were found with secondary spines from December through July.

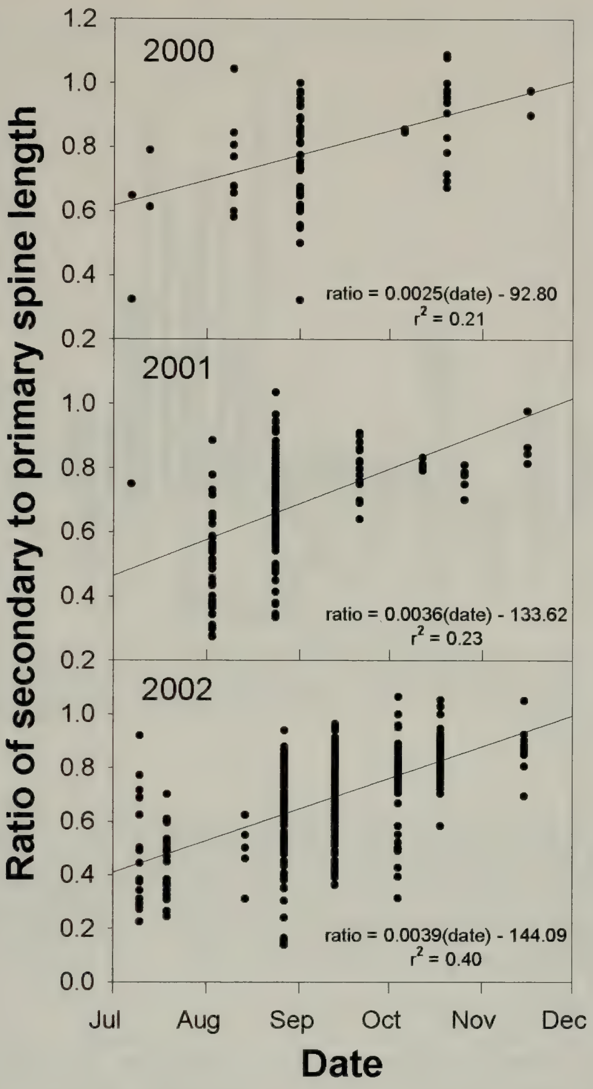

Fig. 3. Ratio of secondary to primary spine length for individual rays during the spine replacement period (July through December) for 2000 through 2002. Linear regression equations and r^2 values are shown for each data set ($p < 0.001$ for all).

within 1.6 km of the initial capture site and nine of the 13 rays were recaptured within a few hundred meters of the initial capture site. The time at liberty of these rays ranged from six to 259 d, with a mean of 79 ± 68 d ($\bar{x}$ ± SD). Minimal growth of clipped spines (< 2 mm) was observed from recaptured rays examined. Observations of captive tagged rays indicated high survivorship (100%) and tag retention (100%) out to a period of 9 months.

Reported Injuries

From 1998, when the Seal Beach lifeguards began keeping records of stingray-related injuries, through 2002, an average of 279 ± 77 (± SD) stingray-related

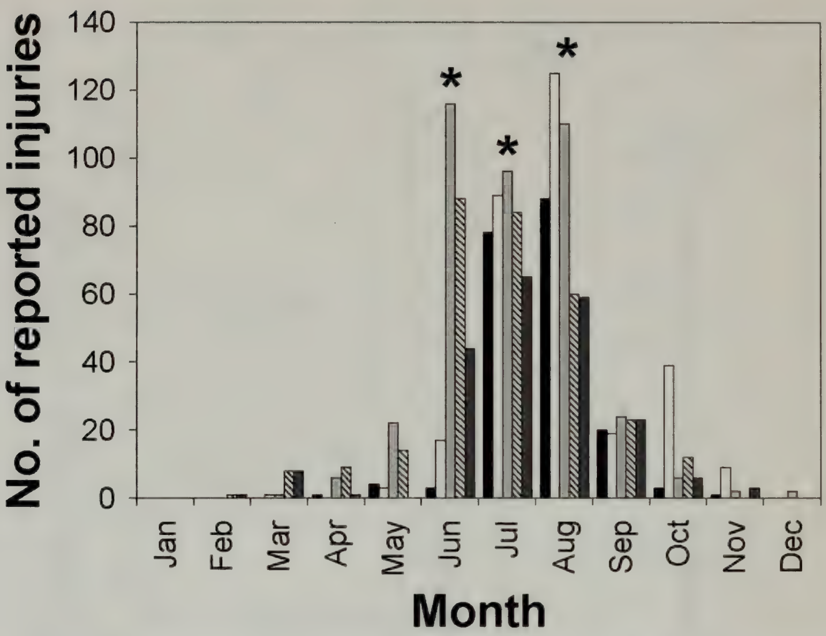

Fig. 4. Monthly number of reported stingray-related injuries at Seal Beach, CA for the years 1998 (black bars), 1999 (white bars), 2000 (light gray bars), 2001 (hatched bars), and 2002 (dark gray bars). Spine-clipping was initiated in 2000. Asterisks denote months with significantly higher numbers of injuries over all years pooled.

injuries have been reported each year, with significantly higher numbers of injuries occurring during the months of June, July, and August (Two-way ANOVA: *df* = 11,44, $p < 0.001$) (Fig. 4). However, there was no significant difference in the monthly occurrence of reported injuries before and after the inception of the spine-clipping program (Two-way ANOVA: *df* = 4,44, $p = 0.16$).

Catch per Unit Effort (CPUE)

The number of round stingrays caught per seine tow (CPUE) was highly variable during the project, but did not vary significantly by month (ANOVA, *df* = 11,30, $p = 0.49$) (Fig. 5). Mean daily CPUE was 56 ± 82 rays per tow. When years were pooled there was a significant positive relationship between mean CPUE and mean number of injuries reported per month (linear regression, *df* = 1,10, $r^2 = 0.33$, $p = 0.052$).

Discussion

The round stingray, *Urobatis halleri,* exhibits annual caudal spine replacement, with secondary spine growth occurring during the summer through fall. The percentage of captured round stingrays with two spines peaked in August and September, exceeding 80% in 2001 and reaching 100% in 2002 (Fig. 2). The high percentage of round stingrays possessing secondary spines in these years suggests that most, if not all, of the population undergoes an annual molt. However, fewer than 60% of the round stingrays caught in 2000 possessed secondary spines, which is likely attributable to insufficient sampling during the expected peak time

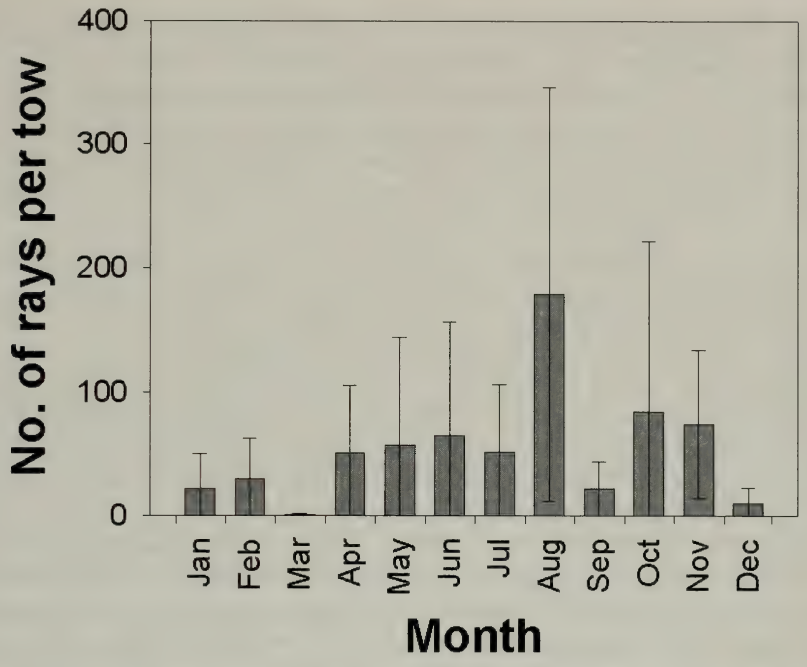

Fig. 5. Mean number of rays per beach seine tow (± SD) pooled by month over the three-year sampling period (2000–2002).

of secondary spine occurrence. The greatest sampling effort and sample sizes generally occurred in 2002, which may represent the best estimate of peak secondary spine occurrence during this study. It is also possible that the exact timing of peak spine replacement may vary slightly from year to year, perhaps due to environmental factors such as food availability or water temperature.

The Atlantic stingray, *Dasyatis sabina* (Lesueur), exhibits an annual spine replacement cycle very similar to round stingrays at Seal Beach; with secondary caudal spines first appearing in June, and all primary spines being shed by November (Teaf and Lewis 1987; Amesbury and Snelson 1997). However, not all stingrays follow an annual spine replacement cycle, with several stingray species within the family Potamotrygonidae shedding their spines every six months and replacement spines alternating between the dorsal and ventral position, relative to the primary spine (Thorson et al. 1988). In contrast, we observed all secondary spines ventral and slightly posterior to the primary spine in round stingrays. These species specific differences in spine shedding periodicities may be related to differing predation pressures or somatic growth rates.

One individual round stingray possessed two fully developed spines in February when all other round stingrays possessed one. A similar exception was reported by Amesbury and Snelson (1997), who observed one anomalous Atlantic stingray with two spines in February, which they attributed to retarded spine growth, and another with two spines in May, which was attributed to improper molting. Although we are not certain why one round stingray possessed two spines in February, it may be that a ray with supernumerary spines underwent spine-shedding at a different time than the majority of the population. We observed six round stingrays with three spines and Russel (1955) likewise reported up to 4 spines in round stingrays, suggesting a small degree of variation in spine numbers within the population. It is unknown, however, when and how many spines are shed in round stingrays with multiple supernumerary spines. Alternatively, two fully developed spines in February could be the result of trauma to the spine, which may have caused the individual to be out of phase with the remainder of the population (Johansson et al. 2004).

A qualitative examination of tag-recapture data suggests that a large, mobile population of round stingrays exists at Seal Beach, California. In addition, recaptured rays showed minimal growth of clipped spines during the periods they were recaptured. This is largely attributed to most recaptures occurring during fall months when rays would have already shed primary spines and their secondary spines would be of maximum size. Although the low recapture rates could be due to high mortality of stingrays caused by catch and release tagging trauma, this is unlikely based on the high survivorship and tag retention of rays captured in beach seines and maintained in captivity for periods up to two years. Low recapture rates may be attributed to the relatively small sampling area compared to the total available habitat; however, the possibility of this is reduced due to the large number of seines conducted. Therefore, the implications of a low recapture rate despite large seine catches are most likely attributable to large population size and that rays are leaving the area within several days to weeks after catch and release (Vaudo and Lowe 2006).

Because there is minimal fishing effort for stingrays outside of the Seal Beach sampling area (e.g., local fishing piers), recapture rates at locations other than Seal Beach were low. Rays recaptured in this study showed a maximum distance traveled of 1.6 km with a mean time at liberty of 79 ± 68 d. However, other studies have indicated that round stingrays are capable of traveling greater distances. Of 482 round stingrays tagged at multiple locations from Santa Monica, CA to Oceanside, CA, 61 were recaptured over a period of 4–14 months (Russel 1955). Thirty-two of the 61 rays were recaptured in the same place as original capture, but 10 were recaptured more than 15 km from the original capture site. Babel (1967) found one tagged round stingray 4.75 km from the initial point of capture after 208 d at liberty. In a more detailed study of movement patterns, Vaudo and Lowe (2006) used a combination of acoustic telemetry techniques to quantify short-term fine-scale movements and site fidelity of round stingrays to Seal Beach. Rays caught and tagged at Seal Beach remained within the area for up to several days and then moved up to several kilometers along the coast. Some rays were also found to leave Seal Beach in the fall and returned the following summer. Although it is not known how far rays disperse from Seal Beach, one ray was found to move from Seal Beach to Newport Bay and back within a period of three months, covering a linear distance of 60 km.

Catch data (CPUE) indicates that some rays are present at Seal Beach year round, although there was a large seasonal variation in ray numbers. When CPUE data were pooled for the three years no significant monthly differences were found. However, when monthly CPUE values were examined over individual years, higher numbers of round stingrays were caught during the summer and fall, with numbers decreasing during the winter months. This is supported by findings of Hoisington and Lowe (2005) who used a combination of beach seining and diver surveys to quantify abundances and densities of round stingrays at Seal Beach. Rays were more abundant and occurred in higher densities at Seal Beach than at neighboring beaches and were most often found within 30 m of the shoreline, where the water was warmest. Ray abundance was found to decrease following periods of high wave activity. Therefore, the high inter-annual variability in ray CPUE may be related to annual weather patterns and periods of high surf activity (Hoisington and Lowe 2005; Vaudo and Lowe 2006).

CPUE data taken in conjunction with tag-recapture data suggest that a large population of round stingrays inhabit Seal Beach. Monthly beach seines revealed high CPUE values during summer and fall months, but yielded very few recaptures, indicating a very high turn over of rays at Seal Beach. Large populations of round stingrays have been noted in other locations in southern California. In a comprehensive fish survey of San Diego Bay, Allen *et al.* (2002) found round stingrays comprise up to 25% (687 kg) of the total fish biomass sampled, although seasonal abundance varied, rays were consistently more abundant throughout the year in San Diego Bay than at Seal Beach. This suggests that round stingrays form aggregations at Seal Beach, but leave the area after periods of several weeks.

Stingray-inflicted injuries to beachgoers primarily occurred during the summer months with few injuries reported during the winter months. Periodic beach counts by Seal Beach lifeguards indicate dramatically higher beach attendance during summer months (June–August) (Capt. R. Pounds, Seal Beach Lifeguards, pers. comm). Analysis of shark attack data by Baldridge (1974) also indicated that most shark attacks occurred during the summer months, which was attributed to the increase in the number of recreational water-users during these months, which would increase the probability of interaction. Some of the variability in the reported number of stingray-inflicted injuries at Seal Beach versus ray CPUE may be better explained by the increasing numbers of beach users at Seal Beach during the summer months.

The primary focus of this study was to determine whether caudal spine clipping of round stingrays at Seal Beach could be used as a management alternative to culling to reduce injuries to beach goers. However, round stingrays were found to aggregate in high numbers at Seal Beach during summer and fall months during the same periods when the beach is most frequently used by beachgoers (Hoisington and Lowe 2005). While rays aggregate in large numbers at Seal Beach, they also exhibit high turn over, making it difficult to capture and treat a large enough percentage of the population to significantly reduce the number of rays with functional caudal spines. In addition, round stingrays naturally undergo caudal spine-shedding in early fall, during periods of their peak abundance at Seal Beach and because they exhibit seasonal fidelity to Seal Beach (Vaudo and Lowe 2006), spine-clipping would have to be done annually. Even though 2,183 rays were caught and spine-clipped over a 2.5-year period, no significant effect on the number of reported injuries at Seal Beach was observed since the program's initiation. Thus, it can be concluded that the rapid regeneration and annual shedding of caudal spines, along with the suspected large population size of round stingrays at Seal Beach, makes caudal spine-clipping, at the level used in this study, an ineffective technique for reducing stingray induced injuries.

Acknowledgments

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Literature Cited

Allen, L.G., Findlay, A.M. and C.M Phalen. 2002. Structure and standing stock of the fish assemblages of San Diego Bay, California from 1994 to 1999. Bulletin of the Southern California Academy of Sciences, 101:49–85.

Amesbury, E. and F.F. Snelson. 1997. Spine replacement in a freshwater population of the Atlantic stingray, *Dasyatis sabina.* Copeia, 1997:220–223.

Babel, J.S. 1967. Reproduction, life history, and ecology of the round stingray, *Urolophus halleri* Cooper. California Fish and Game, 137:1–104.

Baldridge, D.H. 1974. Shark attack. Berkeley Medallion Books: New York. 263p.

Ebert, D.A. 2003. Sharks, Rays, and Chimaeras of California. University of California Press: Berkeley, CA. 274p.

Hoisington, G. and C.G. Lowe. 2005. Abundance and distribution of round stingray, *Urobatis halleri,* near a thermal outfall. Marine Environmental Research, 60:437–453.

Jolly, G.M. 1965. Explicit estimates from capture-recapture data with both depth and immigration-stochastic model. Biometrika, 52:225–246.

Johansson, P.K.E., Douglass, T.G. and C.G. Lowe. 2004. Caudal spine replacement and histogenesis in the round stingray, *Urobatis halleri.* Bulletin of the Southern California Academy of Sciences, 103:115–124.

Kizer, K.W. 1990. When a stingray strikes—treating common marine envenomations. The Physician and Sports Medicine, 18:93–109.

Russel, F.E. 1953. Stingray injuries: a review and discussion of their treatment. American Journal of Medical Science, 226:611–622.

Russel, F.E. 1955. Multiple caudal spines in the round stingray, *Urobatis halleri.* California Fish and Game, 41:213–217.

Teaf, C.M. and T.C. Lewis. 1987. Seasonal occurrence of multiple caudal spines in the Atlantic stingray, *Dasyatis sabina* (Pisces: Dasyatidae). Copeia, 1987:224–227.

Thorson, T.B., Langhammer, J.K. and M.I. Oetinger. 1988. Periodic shedding and replacement of venomous caudal spines, with special reference to South American freshwater stingrays, *Potamotrygon* spp. Environmental Biology of Fishes, 23:299–314.

Vaudo, J.J. and C.G. Lowe. 2006. Movement patterns of the round stingray, *Urobatis halleri* (Cooper), near a thermal outfall. Journal of Fish Biology, 68:1756–1766.

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Spatial and Temporal Patterns of Lobster Trap Fishing: A Survey of Fishing Effort and Habitat Structure

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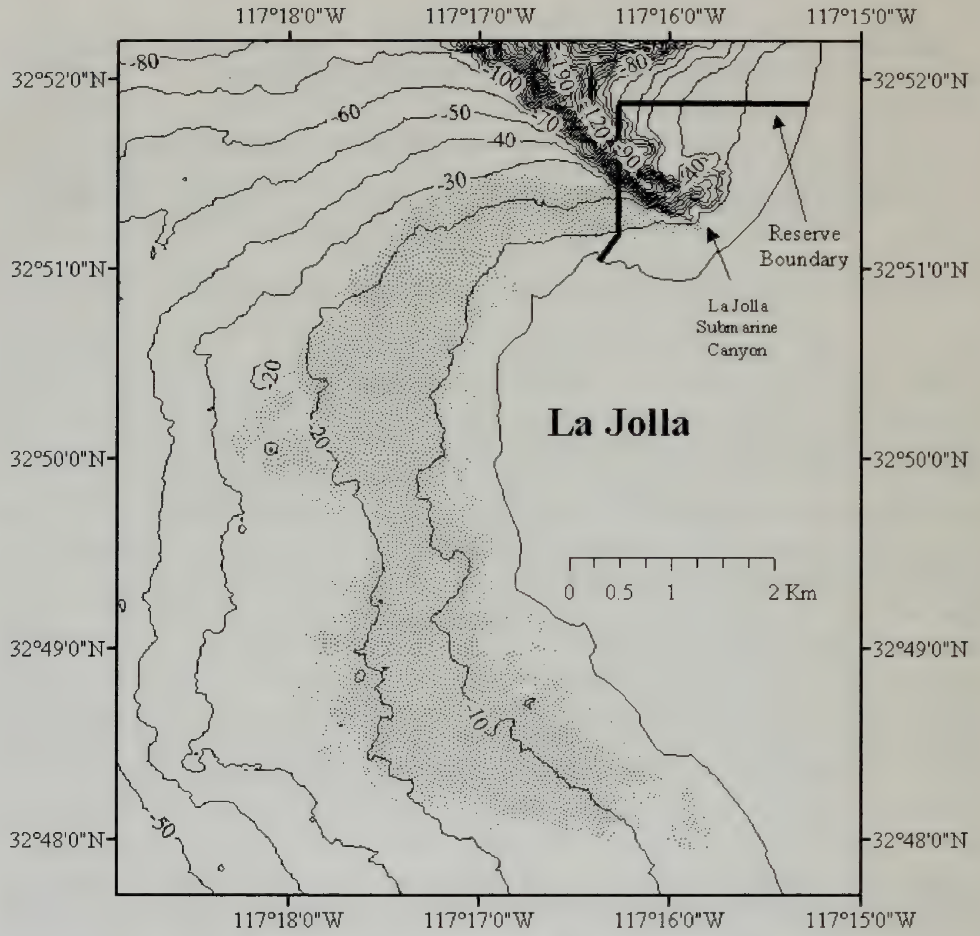
Abstract.—The patterns of distribution and abundance for the California spiny lobster (*Panulirus interruptus*) within the kelp forest off La Jolla, CA (USA) were compared to the distribution of fishing effort during the 2005/2006 lobster season over an area of ~20.25 km^2. Fishing intensity was greatest at the beginning of the season (3333 traps on opening day) decreasing to 258 traps a few days before the end of the 24 week-long season. The collective effort of the trap fishermen primarily targeted the best habitats at the scale of the kelp forest, but fishing effort at smaller scales (250m, the smallest scale of our study) was less correlated to the best lobster habitats, especially near the beginning of the season. Fishing efficiency (CPUE) decreased linearly throughout the season, decreasing by more than an order of magnitude despite the fact that the distribution of fishing effort was better correlated with habitat quality and distribution near the end of the season. Fishing effort was greatest throughout the season at the edge of a small no-take marine protected area indicating possible fishing of spillover.

Successful commercial fishermen base their effort on knowledge that can transcend generations of observation and experience. Their knowledge accrues over relatively large areas and over long temporal periods that allow the fishermen to adjust their effort to all sorts of environmental contingencies. Ecologists and fishermen share an interest in roughly the same questions about resources, but ecologists are traditionally constrained to relatively small scales in time and space. It is important to incorporate the experiential knowledge of fishermen into the body of knowledge developed by scientists. Spatial information can be the means to a common language for communicating fishermen's knowledge to the scientific and management community and vice versa.

This paper compares the fishing effort of lobster fishermen working in the La Jolla kelp forest with a scientific study of the habitat. Specifically, we investigate the relationship between the benthic structure of the fishing ground and the spatial and temporal distribution of fishing effort on spiny lobster (*Panulirus interruptus*). We seek to describe the fishing effort and understand this effort as the result of the collective behavior of several fishermen fishing with different intensity and experience. Such a constructive interaction has developed for the American lobster fishery in New England (Steneck & Wilson 2001).

Methods

The seafloor off La Jolla (Fig. 1) provides a large suitable habitat for spiny lobsters that supports an important fishery. The habitat off La Jolla includes shal-


117°18'0"W
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117°15'0"W
32°52'0"N
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32°49'0"N
32°48'0"N
-80
-60
-50
-40
-30
-100
-90
-120
-70
-20
-10
-50
Reserve Boundary
La Jolla Submarine Canyon
La Jolla
0 0.5 1 2 Km

Fig. 1. Map of the seafloor off La Jolla indicating the locations of the La Jolla kelp forest (stippled area) and the San Diego-La Jolla Ecological Reserve. The northernmost portion of the kelp forest and the head of the La Jolla Submarine Canyon are protected within this Reserve. Depth contour units are contours.

low surf grass beds, shallow rocky habitat with a high degree of vertical structure and crevices, and deeper rocky habitat characterized by boulder and outcrop reefs, ledge and crevice systems and boulder and rock fields. The area also supports the second largest kelp forest off California and includes the San Diego-La Jolla Ecological Reserve. The reserve is a 'no-take' marine reserve established in 1971 to protect the southern margin of La Jolla Bay where several types of habitats are found including kelp forest habitat, shallow boulder-reef habitat, sloping sandy shelf habitat, and the head of the La Jolla Submarine Canyon.

The distribution of fine-scale habitats within the La Jolla kelp forest and the affinity of twenty exploited species (including spiny lobsters) to these habitats was determined as part of a different study (see Parnell et al. 2005; Parnell et al. 2006). The habitat survey was stratified using a grid system in which boxes were 250 m on a side (this scale was derived from a pilot study of the spatial scale of habitat variability off La Jolla). Habitat parameters, fish and invertebrates were

Table 1. Primary and secondary characteristics of habitat types within the La Jolla kelp forest and the fractional affinity of spiny lobster to each habitat. Primary habitat characteristics are the characteristics that were the greatest within that particular habitat, and secondary characteristics are those whose values were >75% of the value for the habitat where each characteristic was greatest.

Habitat	Primary Characteristics	Secondary Characteristics	Lobster Affinity
RTR	reefs, *Eisenia arboria, Cystoseira osmundacea,* red turf algae, articulated coralline algae	sand, var(depth), relief, ledges, crevices, overhangs, *Laminaria farlowii*	0.347
RSUR	bedrock, rock, var(depth), relief, overhangs, *Agarum fimbriatum, Desmerestia ligulata,* brown turf algae	reefs, crevices	0.310
CanG	crevices, *Macrocystis pyrifera,* crustose corraline algae	bedrock, bedrock with sand, ledges	0.216
UG	bedrock with sand, ledges, *Pterygophora, californica, Laminaria farlowii*	*Desmerestia ligulata,* articulated coralline algae	0.095
CobG	cobble, sand	*Pterygophora californica*	0.068

surveyed along randomly-placed 30m band transects within the stratified grid system. Each box within the grid was targeted randomly and several (4–12) transects were surveyed within each box. Habitat parameters including depth variability (var(depth)), vertical relief, bottom substrate, bottom features (reefs, crevices, ledges, and overhangs), and algal guilds were analyzed using divisive clustering analysis. Five robust nominal habitats, determined by resampling the data, were discriminated using this approach. The affinity of lobsters to these habitats was determined from lobster densities estimated from counts along the habitat transects. The proportional affinity of spiny lobster (proportion of lobsters surveyed within a particular habitat type throughout La Jolla) varied significantly among the habitats. The five habitats were named for unique characteristics: "red turf reefs" (RTR), "red sea urchin reefs" (RSUR), "canopy gardens" (CanG), "understory gardens" (UG), and "cobble gardens" (CobG). The primary characteristics of these habitats and the proportional affinity of lobsters (fraction of lobsters surveyed within a particular type of habitat throughout La Jolla) to these habitats are listed in Table 1. Knowledge of how these habitats are distributed within La Jolla and their importance to spiny lobster provides a framework with which to compare the distribution of commercial fishing effort for lobsters.

Lobster trap floats were visually counted throughout La Jolla from the 4m to the 33m depth contours (an area of ~20.3 km^2) during the 2005/2006 lobster season. Lobster trap floats reflect the location of lobster traps on the bottom because the floats are attached to traps by lines having minimal scope to minimize trap loss due to fouling or propeller damage. Floats were visually counted within a grid composed of boxes 250 m on a side that corresponded exactly to the grid system used for the habitat study. Floats were surveyed four times throughout the season − 5 Oct (opening day; T1), 26 Oct (T2), 11 Jan (T3), and 15 Mar (T4). Sampling days were chosen to avoid stormy periods. The lobster season of 2005/2006 opened to commercial fishing on 5 Oct, 2005 and closed on 22 Mar, 2006. Lobster traps were repeatedly surveyed over the course of the lobster season to gauge whether lobster fishermen collectively targeted different habitats with different intensities as the season progressed.

We tested the spatial distribution of traps on all sampling days by dividing the variance by the mean (Index of Dispersion). Values for all days were substantially larger than 1 (see Results) indicating traps were contagiously distributed (c.f., clumped). Frequency distributions of traps (on all days and their average distribution) were then statistically compared to a negative binomial distribution using chi-square tests to determine if the spatial distributions of traps were significantly contagious.

The relationship of fishing effort among days was determined by calculation of a correlation matrix of traps in their respective boxes among the days that the survey was conducted. The observed spatial distribution of traps was observed to be depth-dependant with more traps closer to shore. Therefore the number of traps observed in each box was also correlated with the average depth within each corresponding box. All correlations were performed using S-Plus, a statistical program.

The distribution of fishing effort was then related to habitat distribution by correlating the number of traps observed in each box with lobster habitat affinities (from the band transect surveys) within the same area at ever increasing spatial scales. This technique estimates the degree of correspondence between fishing effort and the value of the habitat for lobster over a range of spatial scales. A smaller spatial scale of correspondence implies that fishing effort is better focused on good lobster habitat. A Matlab script file was written to correlate the number of traps to lobster habitat affinity using moving-window averaging (simple averaging). Window sizes within the correlation analysis ranged from 1 box to 64 boxes, roughly half the size of the kelp forest. We assume that areas having the highest habitat affinities are likely the most productive areas to fish simply because they contain more lobsters. P-values of the corresponding correlation coefficients were computed within Matlab (t-statistic having n-2 degrees of freedom).

Lobster catch data (monthly catch data for La Jolla; California Department of Fish and Game block 0842—the block covering the La Jolla kelp forest) for the 2005/2006 season was used to estimate the catch per unit effort for the days that traps were counted. Monthly catch data were divided by the number of lobster fishing days for each month to standardize monthly catch rates to daily rates. A second order regression of standardized daily catch rate as a function of days since the beginning of the season was calculated using S-Plus to estimate daily catch rates for the days that traps were counted. The second order regression of daily catch rates as a function of seasonal day was significant ($p<0.001$; $r^2 = 0.954$).

Results

Fishing intensity decreased as the season progressed (Table 2) from a high of 3333 traps on opening day to only 258 traps near the end of the season. The distribution of traps for each day is shown in Figure 2. Trap distributions varied among days and with depth (Fig. 3). Traps were shallowest on opening day (T1) and near the end of the season (T4). The distribution of traps was deepest and spread over a larger depth range on T3.

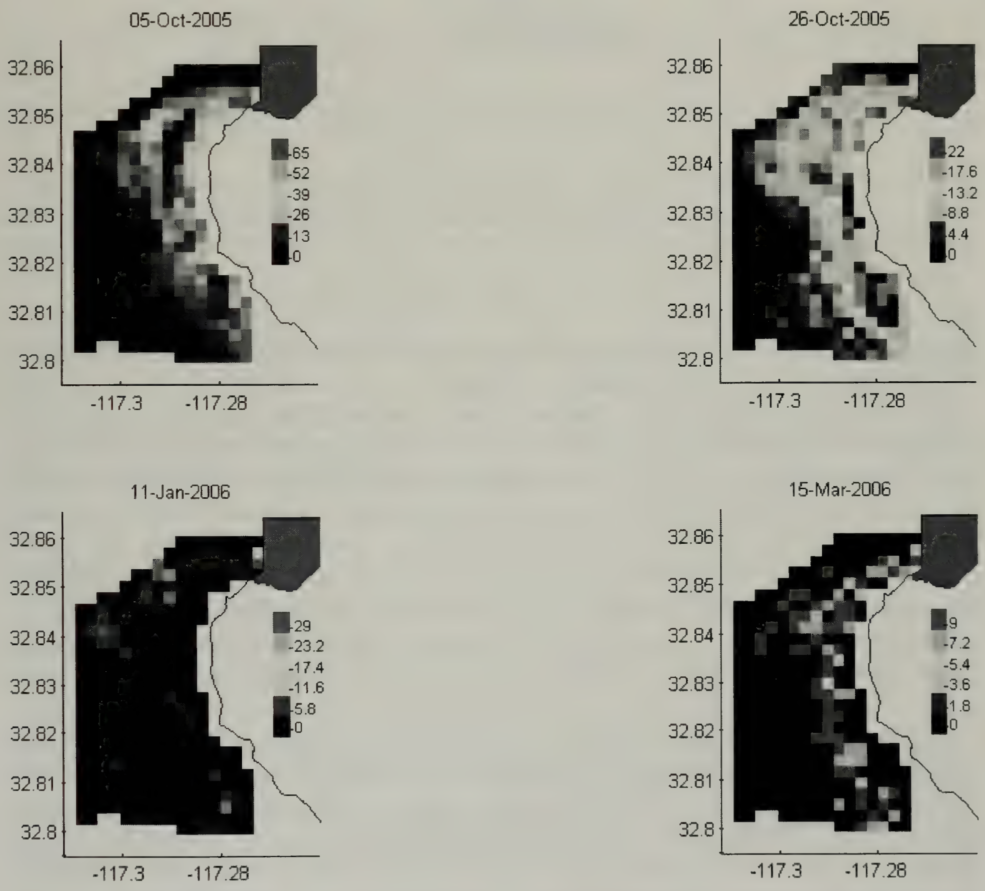
For all days, trap distributions were not significantly different from the negative binomial distribution ($p>0.05$). Therefore, traps were significantly distributed in

Table 2. Summary statistics for the days that traps were surveyed.

Date	Total Traps	Traps Box^{-1} Mean	Traps Box^{-1} S. Error	Index of Dispersion
5 Oct, 2005	3333	10.25	0.53	8.8
26 Oct, 2005	1837	5.65	0.25	3.5
11 Jan, 2006	553	1.70	0.14	3.7
15 Mar, 2006	258	0.79	0.07	2.1

a clumped distribution. Trap distributions for each day of the survey is shown in Fig. 3. Note that there were more traps in northern La Jolla, and that the most heavily fished boxes were in shallow habitat adjacent to the reserve.

The most obvious pattern in the data was the distribution of lobster traps with depth. The correlation of traps (see Table 1) with depth was significant for T1 ($p \cong 0$, $R^2 = 0.48$), T2 ($p \cong 0$, $R^2 = 0.38$), and T4 ($p \cong 0$, $R^2 = 0.21$), but not for T3 ($p = 0.80$). The distribution of fishing effort was significantly correlated among days (Table 3). Fishing patterns were the most similar on the first two


05-Oct-2005

26-Oct-2005

11-Jan-2006

15-Mar-2006

Fig. 2. Traps distributions on all sampling days. Colors indicate the number of traps observed in each sampling box. Note the colorbar scale is different among days. The San Diego-La Jolla Ecological Reserve is shown in grey.

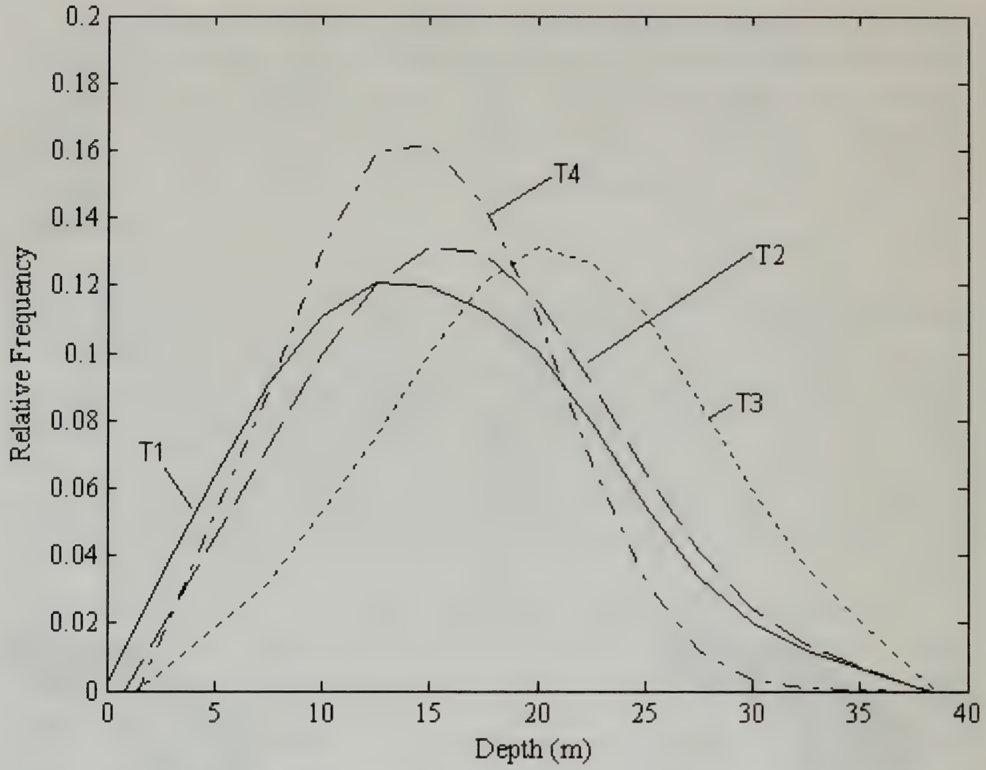


Fig. 3. Relative frequency distribution of lobster traps with depth for each day that lobster traps were surveyed (T1 = opening day of season, 5 Oct 2005; T2 = 26 Oct 20005; T3 = 11 Jan 2006; T4 = 15 Mar 2006).

days of sampling. The distribution of traps on T3 was the most different among the days but was still significantly correlated.

The distribution of habitat value for lobster, derived from SCUBA survey data, is shown in Figure 4. Habitat values are relative to the best-observed habitat for spiny lobsters within the kelp forest. Habitat values for each box were computed as average of habitat affinity among band transects conducted within each box. Kelp forest habitat extends into the Reserve in an area approximately the size of one box and is located next to the western boundary. The habitat within this area is mostly composed of "red turf reefs", which has the highest lobster affinity.

The results of the moving window correlation analysis of fishing effort distribution and habitat affinity are shown in Figure 5. The distribution of fishing effort

Table 3. Matrix of correlation coefficients of trap distributions among days and average box depth. All correlations are significant ($p<0.05$) except for the correlation of T3 with depth.

	Depth	T1	T2	T3	T4
Depth	—	−0.6944	−0.6216	0.0137	−0.4542
T1		—	0.5110	0.2808	0.3477
T2			—	0.2915	0.3827
T3				—	0.4328

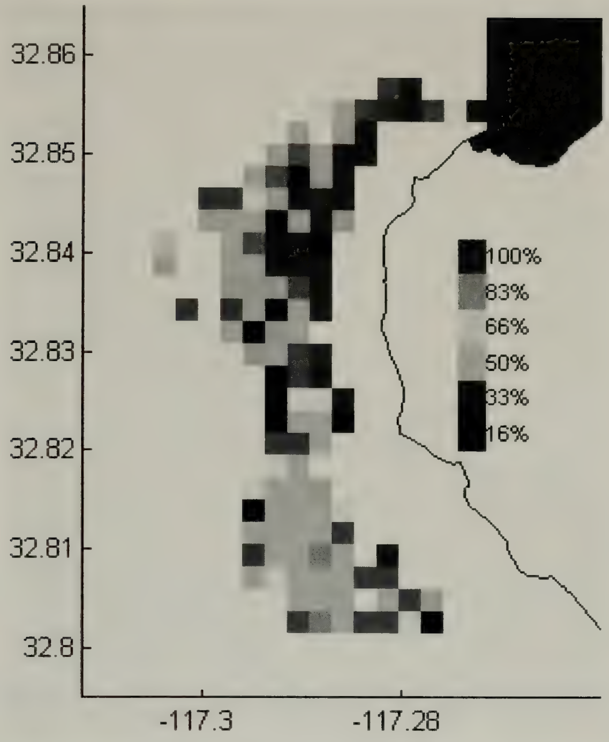


Fig. 4. Distribution of habitat value for lobster within the kelp forest. Colors denote value of habitat to lobster (affinity) relative to the habitat having the highest value (100%).

on T1, T2, and T3 were not closely related at the smaller scales (<~20 boxes) but were closely related at larger scales. Whereas, fishing effort on T4 was more closely related to habitat distributions at smaller scales. Correlations were significant ($p<0.05$) for window sizes greater than 9 boxes for T1, 10 boxes for T2, 12 boxes for T3, and for all window sizes for T4.

Catch per unit effort appeared to decline linearly throughout the season (Fig. 6) and was very low by the end of the season.

Discussion

Our motivation was to evaluate the coupling between fishing patterns in time and space with quantitative scientific determinations of habitat distribution and quality. Fishing patterns for spiny lobster off southern California result from the collective behavior of several independent fishermen with various levels of experience and motivation. The fleet is composed both of very experienced fishermen who have spent their lives in the business and who were taught by previous generations of experienced fishermen, and of less experienced fishermen who are learning their trade. When the season opens, fishermen compete to catch as many legal-sized lobsters as quickly as possible before they are locally depleted. Current management practices limits only the number of fishing permits, not the level of effort expended by each license holder. The spiny lobster fishery off California appears saturated with fishermen as evidenced by the historical reduction in size distributions of lobsters beginning as early as the turn of the last century (Allen

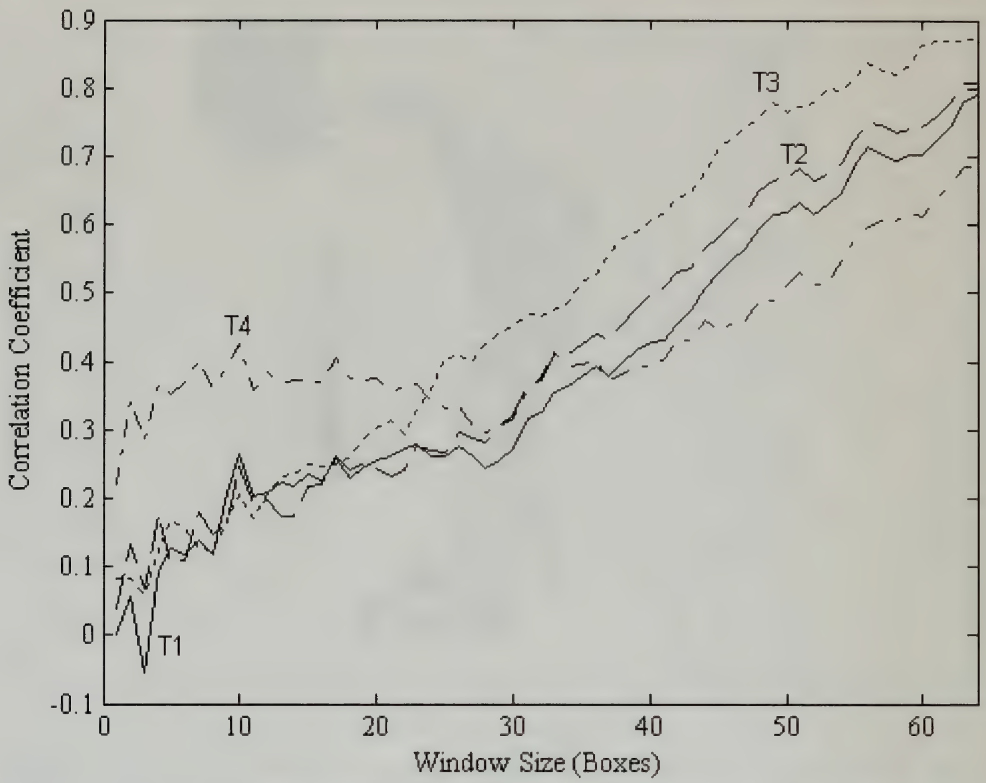


Fig. 5. Results of moving window correlation analysis of habitat value (c.f., affinity) and the distribution of fishing effort. Each curve represents a sampling day. Correlation coefficients were calculated between moving averages of habitat affinity and trap distribution at ever increasing window sizes. Each curve represents one day of the survey.

1913, CDFG 2001). Fishing intensity is dictated by the competition among fishermen as they rush to catch most of the lobsters that have grown to legal size since the previous season. Commercial fishing has been shown to profoundly affect size distributions, fecundity and sex ratio (Iacchei et al. 2005). However, management of the fishery—primarily composed of restricted access permits, size limits, and trap-design rules—appears to be successful. Lobster catch, while fluctuating with the dynamic ocean climate off California, appears stable over the long term. Current management practices were developed in a collaborative effort between the California Department of Fish and Game and the commercial trappers.

The primary results of this study (1) document fishing intensity over time in which the number of traps decreased precipitously from 3333 on opening day to 258 traps remaining just a few days prior to the end of the season, (2) confirm that the collective effort of the fishermen is primarily directed at the better habitats at the scale of the kelp forest but not always at finer spatial scales, (3) indicate that, despite the rapid decline in fishing effort, fishing efficiency (CPUE) decreases throughout the season and is very low by the end of the season, and (4) document a disproportionate fishing effort throughout the season near the edge of the San Diego-La Jolla Ecological Reserve.

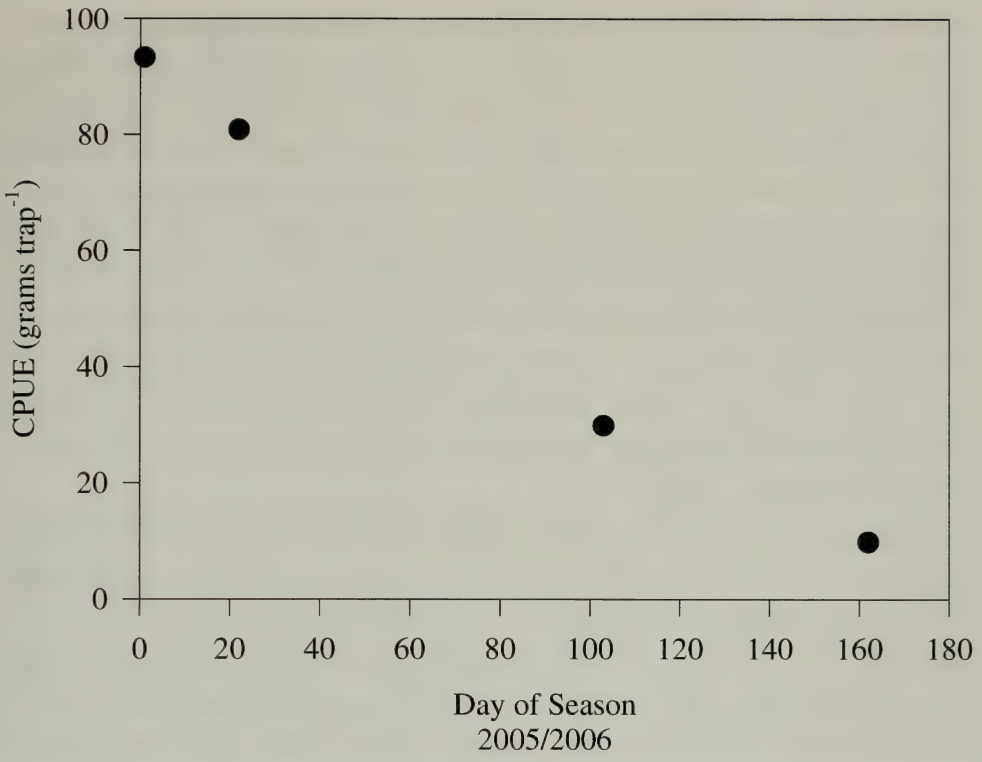


Fig. 6. Lobster CPUE (daily catch modeled using a second order regression from monthly catch data; see methods) plotted against day of the season. Catch data are courtesy of Joann Eres and Jana Robertson of the California Department of Fish and Game.

The fishing strategies of fishermen result from a combination of factors (e.g., see Bene & Tewfik 2001). These include the historical knowledge that accrues across generations about ocean conditions and stock behavior, stock condition, market conditions, risk management, and the cost of fishing. For lobster fishermen in southern California, the primary fishing pattern is to fish shallow in the beginning of the season to exploit the best shallow habitats before the winter storm season arrives and before some portion of the stock (this is not well documented at present) moves into deeper waters during the winter months. The distribution of effort we observed was shallow and intense early in the season, followed by less intense fishing distributed further offshore and across a wider depth zone by mid-season, and a highly focused but greatly decreased effort in shallow waters by the end of the season.

Early in the season there were so many traps that it was impossible to discriminate fishing effort among individual fishermen (floats are painted with distinctive patterns for each fisherman), but by the end of the season it was apparent that nine different fishermen were still fishing and their effort was mostly spread over areas consisting of no more than six of our sampling boxes. The spatial distribution of fishing effort for these nine fishermen best matched our fine-scale habitats. Thus, we assume that these fishermen were highly experienced and knowledgeable. Earlier in the season there was likely a greater mix of experience and knowledge among the fishermen and therefore greater discrepancies between the habitats and fishing effort. Fishermen were still distributing their traps wisely at the scale of the kelp forest, targeting the shallower and northern areas of La Jolla, however, their fishing effort was much less focused on the fine-scale habitats diluting their effort by as much as 400–600 m based on the correlation analysis. This is much greater than the distance lobsters are known to move when they are either home denning (an aggregate working a home range of not greater than ~100 m), or when they are nomadically denning (the aggregate moving farther but still not greater than about 350 m; Stull 1991).

Fishing efficiency decreased throughout the season despite our results that indicate fishermen targeted the most appropriate fine-scale habitats near the end of the season. This suggests that there were few legal lobsters off La Jolla by the end of the season. The effort expended by fishermen is therefore adequate to remove most of the legal-sized lobsters before the end of the season assuming all legal lobsters can be caught.

The last important pattern is that fishing is concentrated near the western edge of the Reserve. This area has good lobster habitat (as defined in Parnell et al. 2006), but it is still fished disproportionately higher than similar habitat further south. This suggests that the fishermen are targeting spillover from the reserve. This argument is further supported by the fact that fishermen are concentrating their traps near the Reserve proportionately more during the middle and latter stages of the season suggesting that most of the legal-sized lobster left by the end of the season are those moving out of the Reserve. Traps were also observed immediately north of the northern boundary of the Reserve during the latter half of the season. This entire area is a sandy shelf and devoid of lobster habitat and therefore was not surveyed for traps. However, the presence of traps in such poor habitat during the latter part of the season, and not near the beginning, further suggests that the fishermen are fishing spillover from the Reserve.

Finally, we advocate that ecologists develop better relationships with the experienced fishermen (e.g., Steneck & Wilson 2001) because the fishermen's experience has provided them with a sophisticated understanding of the behavior of the animals that they exploit, and ecologists have much to learn from them.

Acknowledgments

We would like to thank Jonathon Shaffer, Kristin Riser, and Maiko Kasuya for their help in the field. We also thank Hunter Lenihan and an anonymous reviewer for their comments which helped improve the manuscript. John Guth and Chris Miller, long-time lobster fishermen, provided constructive input.

Literature Cited

Allen, B.M. 1913. The problem of the spiny lobster (*Panulirus interruptus*). Fish Bulletin—California Department of Fish and Game 1:18–26.

Bene, C. and A. Tewfik. 2001. Fishing effort allocation and fishermen's decision making process in a multi-species small-scale fishery: analysis of the conch and lobster fishery in Turks and Caicos Islands 29(2):157–186.

California Dept. of Fish and Game. 2001. California's Living Marine Resources: A Status Report. W.S. Leet, C.M. Dewees, R. Klingbeil, and E.J. Larson (editors). University of California, Agriculture and Natural Resources Publication SG01–11, p. 98.

Iacchei, M., Robinson, P., and K.A. Miller. 2005. Direct impacts of commercial and recreational fishing on spiny lobster, *Panulirus interruptus,* populations at Santa Catalina Island, California, United States. New Zealand Journal of Marine and Freshwater Research 39:1201–1214.

Stull, A.T. 1991. Nightly foraging movements and den fidelity of the California spiny lobster, *Panulirus interruptus,* at Santa Catalina Island, California. MS Thesis, California State University, Long Beach.

Steneck, R.T. and C.J. Wilson. 2001. Large-scale and long-term, spatial and temporal patterns in demography and landings of the American lobster, *Homarus americanus,* in Maine. Marine Freshwater Research 52:1303–1319.

Parnell, P.E., Lennert-Cody, C.E., Geelen, L., Stanley, L.D., and P.K. Dayton. 2005. Effectiveness of a small marine reserve in southern California. Marine Ecology Progress Series 296:39–52.

Parnell, P.E., Dayton, P.K., Lennert-Cody, C.E., Rasmussen, L.L., and J.J. Leichter. 2006. Marine reserve design: optimal size, habitats, species affinities, diversity, and ocean microclimate. Ecological Applications 16:945–962.

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A History of Gila Monster (*Heloderma suspectum cinctum*) Records from California with Comments on Factors Affecting their Distribution

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Abstract.—The Gila monster (*Heloderma suspectum*), widely distributed in parts of the Mojave, Sonoran and Chihuahuan Deserts of the southwestern United States and northwestern Mexico, is rare in California. However, during the last 153 years, as many as 26 credible records have been documented from four California counties. Habitat in which the species has been observed in California is characterized by rocky, deeply incised topography, in most cases, associated with large and relatively high mountain ranges. Most localities are associated with riparian areas (including the lower Colorado River) and range from near sea level to over 1,200 m. All records except one (Mojave River) occur east of about 116° longitude. Records documented with photographs or museum specimens generally show color patterns diagnostic of the geographically expected subspecies *H. s. cinctum.* The distribution of the species in California suggests an invasion into the high mountain ranges of the northeastern Mojave during the last interglacial via the Colorado River corridor. We explored the hypothesis that climate patterns shaped the current distribution of the Gila monster in California. Precipitation is decidedly biphasic east of 116° longitude, with over 24 percent falling in the warm season. Warm season precipitation data from recording stations closest to Gila monster localities are almost identical for those in western Arizona where the species is more common. Summer precipitation may be important in the foraging ecology of the species. Gila monsters were probably already rare in California long before the arrival of Europeans due to changes in climate and landform that delimited the marginal location of California in the range of this species. Fortunately, most of the habitat for this species in California is protected or relatively free from human disturbance.

Rare species present unique challenges to conservation efforts. Not only are rare and secretive species difficult to census, but different types of rarity expose species to different extinction processes and vulnerabilities (Meyers 1997). The Gila monster (*Heloderma suspectum*) is widely distributed in the southwestern United States and northwestern Mexico, especially in the Sonoran Desert (Stebbins 1985; Brown and Carmony 1991), but rare in California. The latitudinal distribution of the species extends from about 25–35° north latitude, a distance of over 1,000 km. Throughout this range the species occurs primarily in desert scrub habitats (Beck, 2005; Beaman et al., 2006) but also occupies a variety of habitats including thorn scrub, riparian, xero-riparian, desert grassland, and oak woodland plant associations from near sea level to over 1,500 m elevation (Bogert and Martín del Campo 1956; Brown and Carmony 1991). Despite a wide distribution in the hot deserts of North America, records for the Mojave and Colorado Deserts (the latter a subdivision of the Sonoran Desert [Burk 1977]) of California have been rare, scattered and sporadic (Table 1). The Gila monster is protected in California as a species of Special Concern. Effective conservation of such a rare species requires an understanding of the factors that define its rarity, whether natural or anthropogenic.

The objectives of this paper are twofold. First, we consolidated and reviewed all known information on this species in California. Since the literature on Gila monster records in California is diffuse, dated, and often cited in obscure references and reports, summaries and previously unpublished details are also excerpted in the discussion below for the sake of completeness. Photographs of all known Gila monsters from California are included herein, most of which have never been published. Observations were considered to be credible based on any one or more of the following criteria: existence of a voucher specimen or photograph, publication of the record in a peer-reviewed journal, the veracity of the observer(s), or the fact that independent observers, familiar with an area, reported sightings in the same area as other credible records. We recognize that our criteria may not be acceptable to all. For example, based on the existence of a vouchered specimen from the same mountain range, and other sightings in the area, we consider the Green's Well record in Table 1 to be credible despite the fact that the author who reported it does not (Mitchell 1978).

Our second objective was to evaluate existing data to determine the critical factors influencing the distribution of this species in California.

History of Gila Monster Records for California

Mojave River.—Baird (1859) was the first to mention a specimen from the "Mohave river" in his publication listing the reptiles of the Pacific Railroad Survey. Since the Mojave River (about 200 km in length) lies entirely in San Bernardino County, California, the largest county in the United States, the exact provenance of the specimen is impossible to ascertain beyond what is given, an ambiguity not unlike others attributed to Baird (Montanucci, 2001). The specimen is almost certainly one catalogued in the National Museum of Natural History as USNM 228171 (Steve Gotte, pers. comm.) and is represented by a partial skull, hyoid and trachea, and a partial post-cranial skeleton. The locality data in the National Museum reflects Baird's designation with the spelling variant "Mojave River."

The USNM mammal bone catalogue (where the specimen was originally cataloged as #4401) lists Caleb B.R. Kennerly as the collector and Amiel W. Whipple as the donor. Whipple was in charge the Pacific Railroad Surveys along the 35th parallel and Kennerly was his Surgeon/Naturalist. The specimen was most likely collected sometime in 1853–4 although it was not catalogued until 1861. Most of the specimens listed by Baird include USNM numbers that were assigned in mid-1858 (Steve Gotte, pers. comm.). Since the specimen was not cataloged until 1861, Baird listed no number, thus supporting the conclusion that this was the

Table 1. List of Gila monster records and locations in California. Geographic coordinates are given as available in the source, or estimated as latitude/longitude or township, range and section from desert maps supplied by the Bureau of Land Management.

County	Location	Date	Reference	Comments
Imperial	Imperial Dam on the Colorado River, 32° 52′ 59″ N; 114° 28′ 1″ W	1964	Funk (1966)	45 m
Inyo	Kingston Range, 5.5 km ENE Horse Thief Springs	5/4/1980	Ford (1981)	945 m
Riverside	Blythe airport	1948	Woodson (1949)	12.7 cm specimen
	Chuckwalla Valley, some 40.2 km NE of Desert Center	"about 4/25/1943"	Tinkham (1971)	Chuckwalla Valley (Granite Mountains?) 750–1,000 m?
San Bernardino	Vulcan Mine Road, Providence Mtns.	4/16/1968	De Lisle (1979)	UTM 3865209N, 629493E (T10N, R13E, Sec 17 fide Brown, 1976)
	Providence Mountains	1978–1982	De Lisle (1983)	9 specimens
	Providence Mountains, Mitchell Caverns	?	Mitchell Caverns staff pers. comm.)	See text. 34.93° North, 115.53° West
	Cadiz Valley, near Iron Mountain	4/8/99	*in litt.*	T1N, R16E, Sec. 19
	Kingston Range, 1.4 km W Porcupine Tank	5/20/1980	Ford (1981)	1,220 m
	Kingston Range, 2.6 km W Kingston Peak	6/3/1980	Ford (1981)	1,130 m
	Kingston Range	2/1981	Ford (1983)	Ron Lee, Nevada Department of Fish and Game
	Kingston Range	5/22/2006	Basey (pers. comm.)	Photo taken
	East flank of Clark Mtn.	1962	Bradley and Deacon (1966)	R665 UNLV collection
	Clark Mtn., 4 km NW Green's Well (T17N, R13E, Sec 8 NW) 1,371 m	1977	Mitchell (1978)	Reliability of record questioned by author
	Clark Mountain, Pachalka Spring	?	*in litt.*	See text
	Piute Creek (Ft. Piute), 45 km NW Needles (T12N, R18E, Sec. 24, NW ¼, NE ¼)	5/9/1982	Bicket (1982)	Photo in publication
	Mojave River	<1861	USNM 228171	
County unknown	Southern California	<1906	CAS 172	

same animal reported in his 1859 paper. Leonhard Stejneger, former curator of the Division of Reptiles and Amphibians at the Smithsonian, was apparently unaware that the specimen existed when he published the results of the Death Valley Expedition (Stejneger 1893).

Bogert and Martín del Campo (1956) considered the Mojave River assignation of Baird to be in error, suggesting that "*. . .the data may originally have been abbreviated as 'Mojave R' and intended to designate the [Fort] Mojave [Indian] R[eservation] (rather than 'River') in western Arizona, where* cinctum *is to be expected.*" However, Baird (1859) clearly designated the river, not the reservation, as the collection locality.

The Southern Pacific railroad parallels the Mojave River along much of its course, from the river's terminus at the Cronese Dry Lakes, in the heart of the Mojave Desert, to near its source, high in the San Bernardino Mountains. Along the Mojave River, the survey would have passed through or near the following mountain ranges: Soda Mountains, Cronese Mountains, Cady Mountains, Calico Mountains, Newberry Mountains, and various low hills and promontories, characterized by Mojave desert scrub vegetation (Vasek and Barbour 1977). None of these ranges greatly exceed about 1,000 m in elevation, and the valley bottoms are about 300–500 m. Historically, habitat along the Mojave River was characterized by dense riparian communities of cottonwood, willow, mesquite and other relict wetland species (Lovich and Meyer, 2002), not unlike the site where the Piute Springs specimen was observed (see below).

Chuckwalla Valley.—Tinkham (1971) reported that "*There are no authentic records to date for the Gila monster in California, nor is there ever likely to be now, since the drought years of the past two decades have been so severe that an examination of the shrubs in almost any location will reveal 50–75% of the desert shrub vegetation as dead or dying.*" His proclamation that the desert was dying from drought was in error, as was his oversight of earlier records of Gila monsters in California reported by Baird (1859), Woodson (1949), Funk (1966), and Bradley and Deacon (1966). His statement is further contradicted by his own admission that, "*There is however, some evidence that the Gila monster had been seen in California prior to 1945. The most likely places are those mountain ranges in the Searchlight, Nevada region.*" He then related a story based on notes he made from statements of a friend named Lyell Howell:

> "*About April 25, 1943, while General Patton's tank corps was on maneuvers in the northeastern section of a branch of Chuckwalla Valley, some 25 miles northeast of Desert Center, a Gila monster was brought into headquarters by some of the men. As Mr. Howell was well acquainted with the chuckwallas, his statement that this specimen was a Gila monster in typical yellow and black markings, is probably correct.*"

If the bearing and distance from Desert Center to the collection site is correct, it would be located somewhere in the Granite Mountains in Riverside County (T2S, R18E, Sec. 28), which border the Chuckwalla Valley, at an elevation of about 750–1,000 m. This part of the range is very dry, without springs or riparian areas, characterized by desert scrub species (e.g., *Larrea tridentata* and *Ambrosia dumosa*), wash woodlands dominated by ironwood (*Olneya tesota*), and rocky

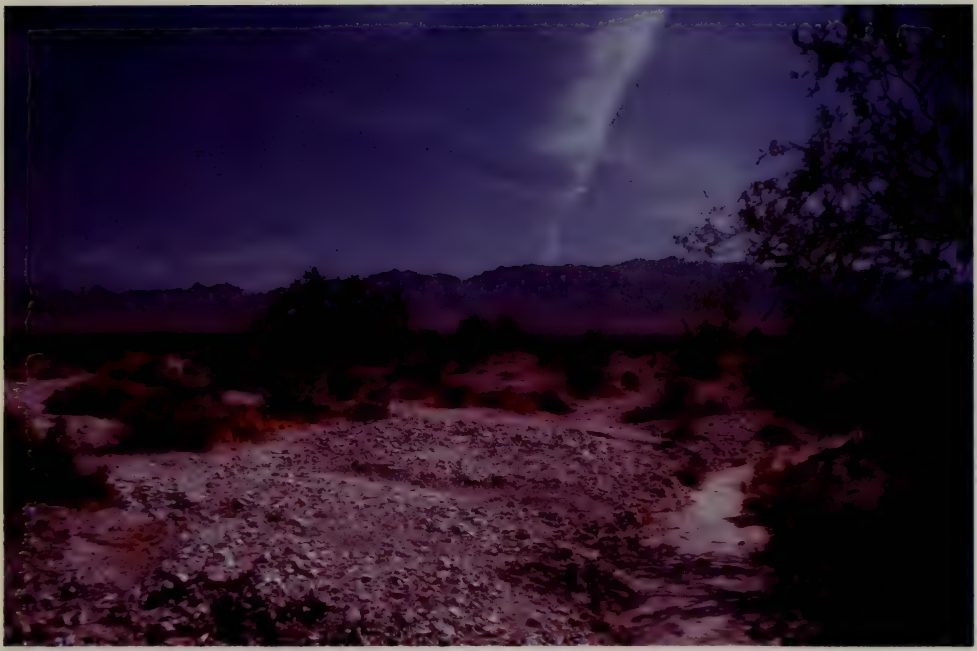

Fig. 1. Ironwood wash woodland near Palen Pass, Riverside County, California. Granite Mountains are in the background. Photo by Jeff Lovich.

hillslopes (Figure 1). The Chuckwalla Valley ranges from 200–350 m at the base of the Granite Mountains.

The locality record was incorrectly reported by Jennings and Hayes (1994), as "*15.5 km east of Desert Center in the Chuckwalla Mountains.*" Similarly, De Lisle (1986) erroneously listed this specimen as "*. . . in the Chuckwalla Mountains, 25 miles east of Desert Center. . .*"

The lower Colorado River.—Woodson (1949) published the details of a newspaper account (without citing the newspaper or date), describing a Gila monster that was discovered "*. . .near Blythe, a few miles west of the Colorado River on the California side.*" Workers uncovered a 12.7 cm juvenile Gila monster while tearing down a building near an airport. In spite of this observation, Woodson did not believe that the species was indigenous to California and considered earlier sightings to be escaped pets or misidentified chuckwallas (*Sauromalus obesus*).

Another Gila monster was killed by a night watchman at Imperial Dam, on the California side of the Colorado River, in June, 1964. The specimen was apparently given to the Arizona Game and Fish Office in nearby Yuma, Arizona, but the final disposition of the specimen is not known (Funk 1966). This was one of several Gila monsters reported by Funk from near Yuma. Observations occurred at elevations 30–45 m above sea level. Vegetation is typical of lower elevations of the Colorado Desert subdivision of the Sonoran Desert, with sandy soils supporting creosote bush (*Larrea tridentata*), burrobush (*Ambrosia dumosa*), and *Ephedra* sp. in well-drained areas, and riparian plant species (*Pluchea sericea, Prosopis juliflora, Tamarix ramosissima*) near the many irrigation canals.

It is worth noting that the record on the California side of the Colorado River

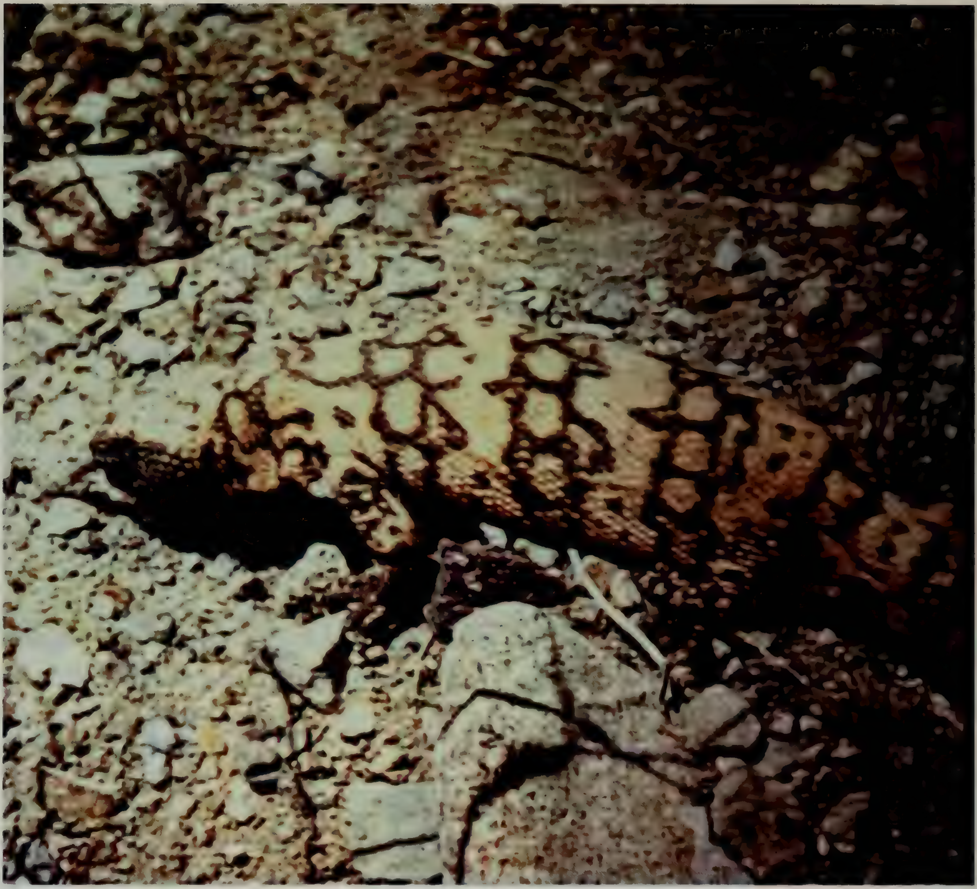

Fig. 2. The Gila monster from the Providence Mountains, Vulcan Mine Road, 16 April, 1968, 1000 hr. Photo is catalogued as Los Angeles County Museum Photographic Catalog (LACMPC) #1331. Photo by Harold De Lisle.

is not the westernmost record of Gila monsters from this area (Funk, 1966). Due to the meandering course of the Colorado River, specimens from near Yuma, Arizona were found about 14.5 km west of the California record above.

Providence Mountains.—With elevations at over 2,000 m, the Providence Mountains are one of the southernmost in a series of Mojave Desert "sky islands" supporting relict populations of plants and animals that survived post-Ice Age changes in climate by retreating to more mesic and temperate climes on their slopes. Around 1000 hr on 6 April, 1968, a Gila monster was observed and photographed by De Lisle (1979) near the Vulcan Mine road on the west side of the mountains (Figures 2 and 3). Recognizing the significance of the find, the author captured the animal and gave it to the Los Angeles Zoo where it was displayed until its death in 1990. The specimen was subsequently donated to the Natural History Museum of Los Angeles County. A recent search of the museum collections failed to locate the specimen and it is presumed lost.

De Lisle discounted the possibility that the specimen was a released captive based on the remoteness of the area, the lack of extensive off-road use of the

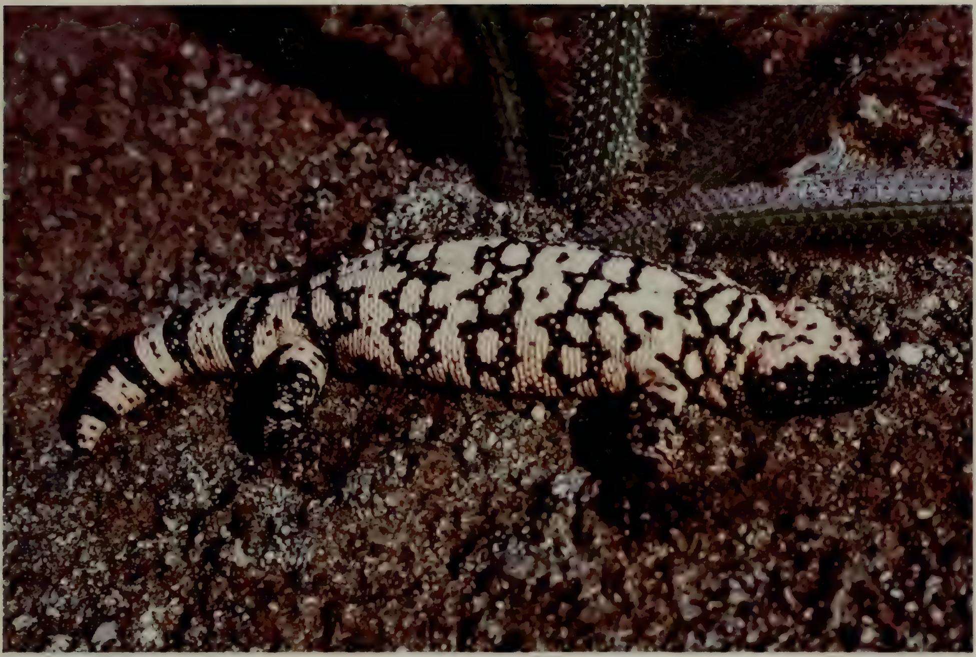

Fig. 3. Same Gila monster in Figure 3 photographed while at the Los Angeles Zoo.

desert at that time, and the fact that the specimen was diagnostic of the geographically expected race, *H. suspectum cinctum.* Figures 2 and 3 clearly show the banded pattern typical of this subspecies. De Lisle (1986) indicated that specimens from the Providence Mountains were mostly pink with a reduction in black pigmentation relative to other *H. suspectum.*

Between 1968 and 1982 nine additional "specimens" were reported from the Providence Mountains (De Lisle 1983), but none were photographed or collected. Conversations with De Lisle indicate that not all were observed in 1982, and at least one may have been sighted in 1978 (De Lisle 1986). De Lisle considered the spate of sightings around 1982 to be attributable to "*some combination of climatic conditions favoring surface activity.*" Further details for the additional nine Providence Mountain "specimens" were not provided by De Lisle, and it is unknown whether the number reflects repeated sightings of an individual or individuals.

Additional Gila monsters may have been observed by state employees at Mitchell Caverns Natural Preserve in the Providence Mountains State Recreation Area, although some of those specimens could include records mentioned by De Lisle (1983; De Lisle, pers. comm.). This site is located on the eastern side of the range, opposite from where De Lisle reported his first specimen. Conversations with these observers indicate that most sightings occurred in May or June along the east side of the trail leading to the cave.

Piute Mountains.—On 9 May, 1982, a Gila monster was photographed (Figures 4 and 5) at Piute Creek (Fort Piute) in the Piute Mountains of San Bernardino County (Bicket 1982). Field notes indicate that the animal was seen at about 1330 hr and was approximately 35.6 cm in length (Bureau of Land Management, *in*

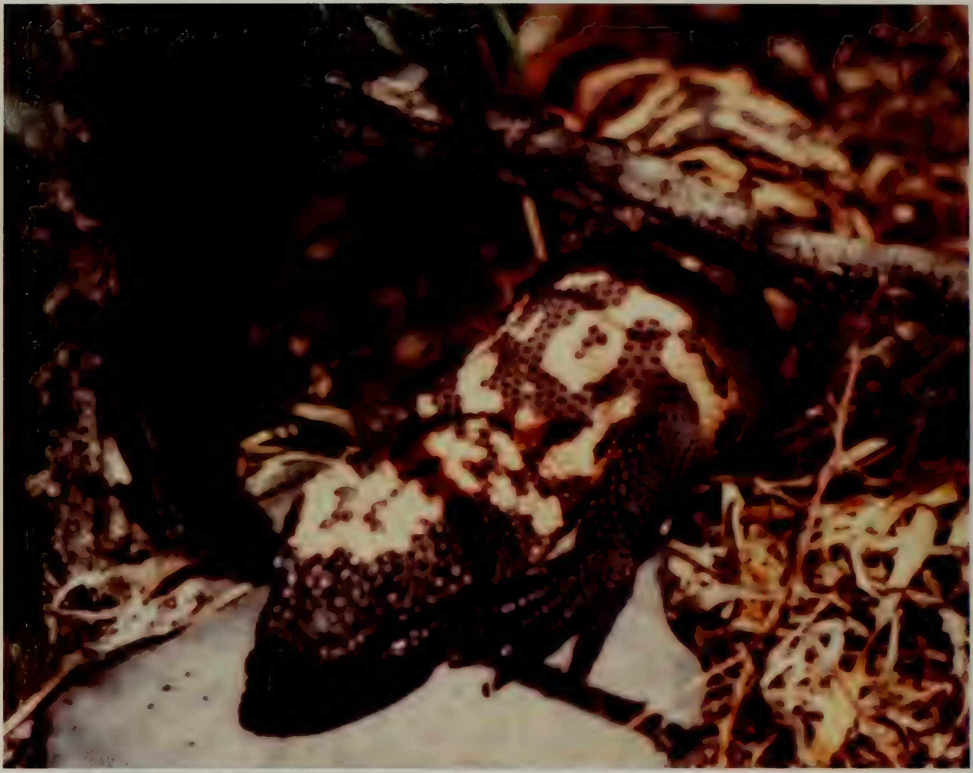

Fig. 4. The Gila monster from Piute Springs (see caption of Figure 3) in riparian streambed. Photo by Ann or Rachel Curren. LACMPC #1364c.

litt.). When observed, it was in a streambed among vegetation and surface litter. The temperature at the time was 18.3° C under sunny, mostly clear skies with winds of 8–16 kph. It had rained "several" days prior to the observation. The elevation at the site is 853 m. Piute Creek is the only perennial stream for many kilometers around and is characterized by typical desert riparian plant species including *Salix* sp., *Baccharis viminea, Prosopis* sp., and *Tamarix ramosissima.* A subsequent herpetological survey of the site did not detect Gila monsters (Hazard and Rotenberry 1996).

Brown (1976) reported that the owner of the YKL Ranch told BLM biologists in 1975 that "*. . .there used to be gila monsters in the northern Piute Range in the vicinity of Stray Cow Well and Willis' Hole. He and his personnel also reported seeing a gila monster along the Old Government Road near Fort Piute several decades ago.*" Stray Cow Well is near the Nevada state line, and Willis' Hole may refer to nearby Lewis Holes, just over the state line in Nevada.

It is worth noting that the pattern exhibited by the specimen in Figures 4 and 5 is more reticulate than photographs of other California Gila monsters in this paper. This pattern is more suggestive of *H. s. suspectum* than of the expected race *H. s. cinctum.*

Kingston Range.—In 1980, three separate sightings of Gila monsters occurred in the Kingston Range of the northeastern Mojave Desert of California during a survey of the natural resources in the area (Stone and Sumida 1983). The Kings-

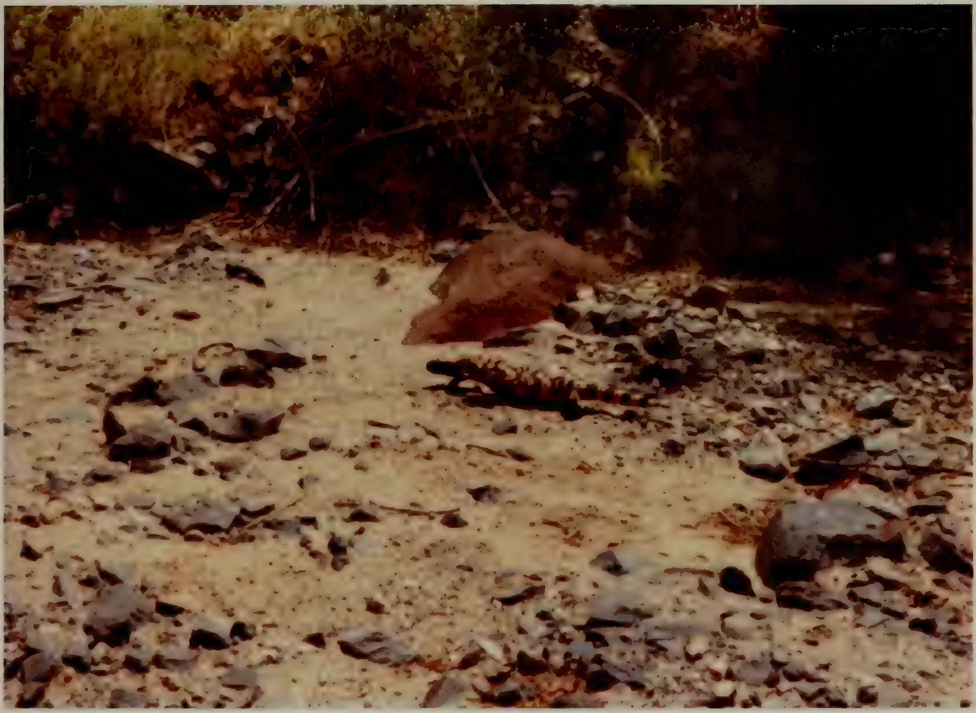

Fig. 5. The Gila monster from Piute Springs (Fort Piute), San Bernardino County, California. Photo by Earl Curran. LACMPC #1364a.

tons are part of a chain of sky islands with elevations exceeding 2,200 m. The first specimen was sighted, and photographed (Figures 6 and 7), 5.5 km eastnortheast of Horse Thief Springs (elevation 945 m) on 4 May, 1980, and is the only documented Gila monster from Inyo County. The second was sighted 1.4 km west of Porcupine Tanks at 1,220 m on 20 May, 1980. The third was seen 2.6 km west of Kingston Peak at 1,130 m on 3 June, 1980. All three occurred in sandy washes associated with large boulders. Plant species in the area included catclaw acacia (*Acacia greggii*), burrobush (*Ambrosia dumosa*), Death Valley ephedra (*Ephedra funerea*), creosote bush (*Larrea tridentata*), and desert almond (*Prunus fasciculata*) (Ford 1981).

A subsequent sighting in February, 1981 by Ron Lee (a Nevada Department of Wildlife technician) was reported by Ford (1983). Additional details of the sighting were not provided. Correspondence to one of the authors (KRB) contains testimony from a Mr. Junior Huffman who claims to have seen two Gila Monsters in the Kingston Range, one in the mid-1970's and the other in the early 1980's, on Furnace Creek Road between the Omega and Standard Slag Iron Mines.

Gila monsters continue to be reported in the Kingston Range. An individual was photographed by R. Terry Basey in a sandy wash in the northwest part of the range on 22 May, 2006, at 10:45 AM. Weather conditions were warm and sunny following the passing of a weak cold front through the area during the early hours of the previous day. That individual also exhibited a strongly banded pattern (Figure 8).

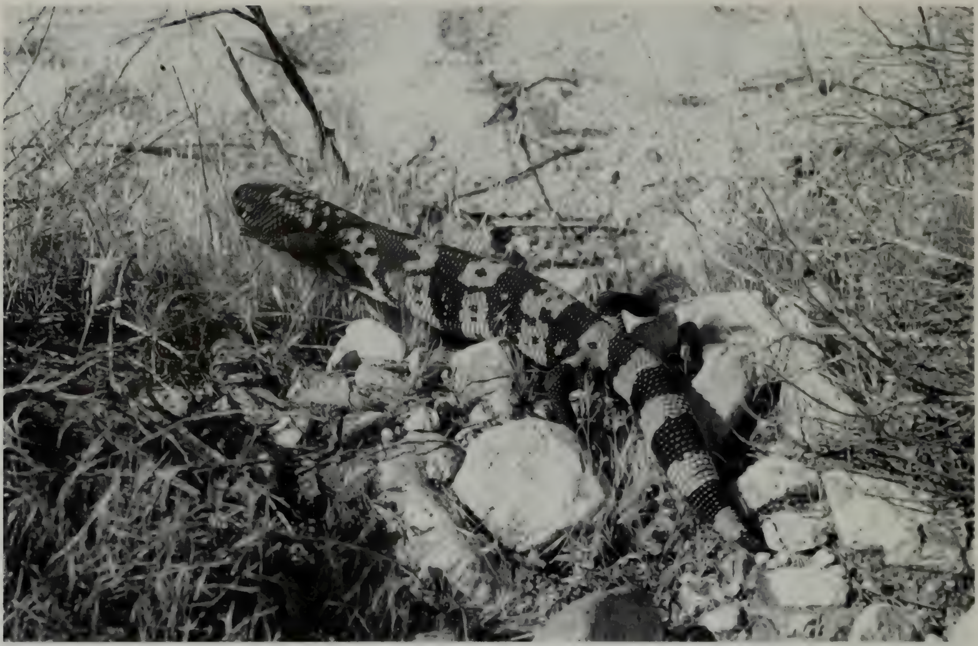

Fig. 6. Gila monster from the Kingston Range, San Bernardino County, California, 1.4 km west Porcupine Flats. Photo by Randall Ford, 30 May, 1980. LACMPC #1329.

Clark Mountain.—At almost 2,400 m, Clark Mountain is the highest of the east Mojave sky island mountain ranges in California. Bradley and Deacon (1966) reported a specimen collected from the eastern slope of the Clark Mountains in 1962 now in the collection of the Marjorie Barrick Museum of Natural History at the University of Nevada, Las Vegas (#R 665, Figure 9). The snout-vent length of the specimen is 267 mm with a total length of 40.5 cm. This collection site is about 11 km southwest of the California-Nevada state line. Several other specimens were reported from nearby Clark County, Nevada, and all were collected at elevations below 1219 m (Bradley and Deacon 1966).

Additional surveys of the Clark Mountain area were conducted by Mitchell (1978) who failed to find additional specimens. However, he interviewed a Mr. Smith who reported seeing a Gila monster in 1977 four km northwest of Green's Well, on the north side of the range, near a dirt road at 1,371 m elevation. The area is characterized by Joshua trees (*Yucca brevifolia*), some desert willows (*Chilopsis linearis*), and many boulders. It was the only Gila monster that Smith observed in 25 years of roaming the Clark Mountain area. Mitchell expressed some doubt concerning the reliability of the report since Mr. Smith could not remember the time of year when he saw the lizard. This is the same Gila monster record reported by De Lisle (1983) for the Clark Mountains (De Lisle, pers. comm.).

In correspondence to one of the authors (KRB) from Dan Guthrie, it was indicated that a Ms. Jan Smith (daughter of long time resident of the Curtis Mine, Mr. Frank Curtis) observed a Gila monster at Pachalka Spring on the west side of the Clark Mountains.

Other sightings and records.—Several other sightings of Gila monsters have

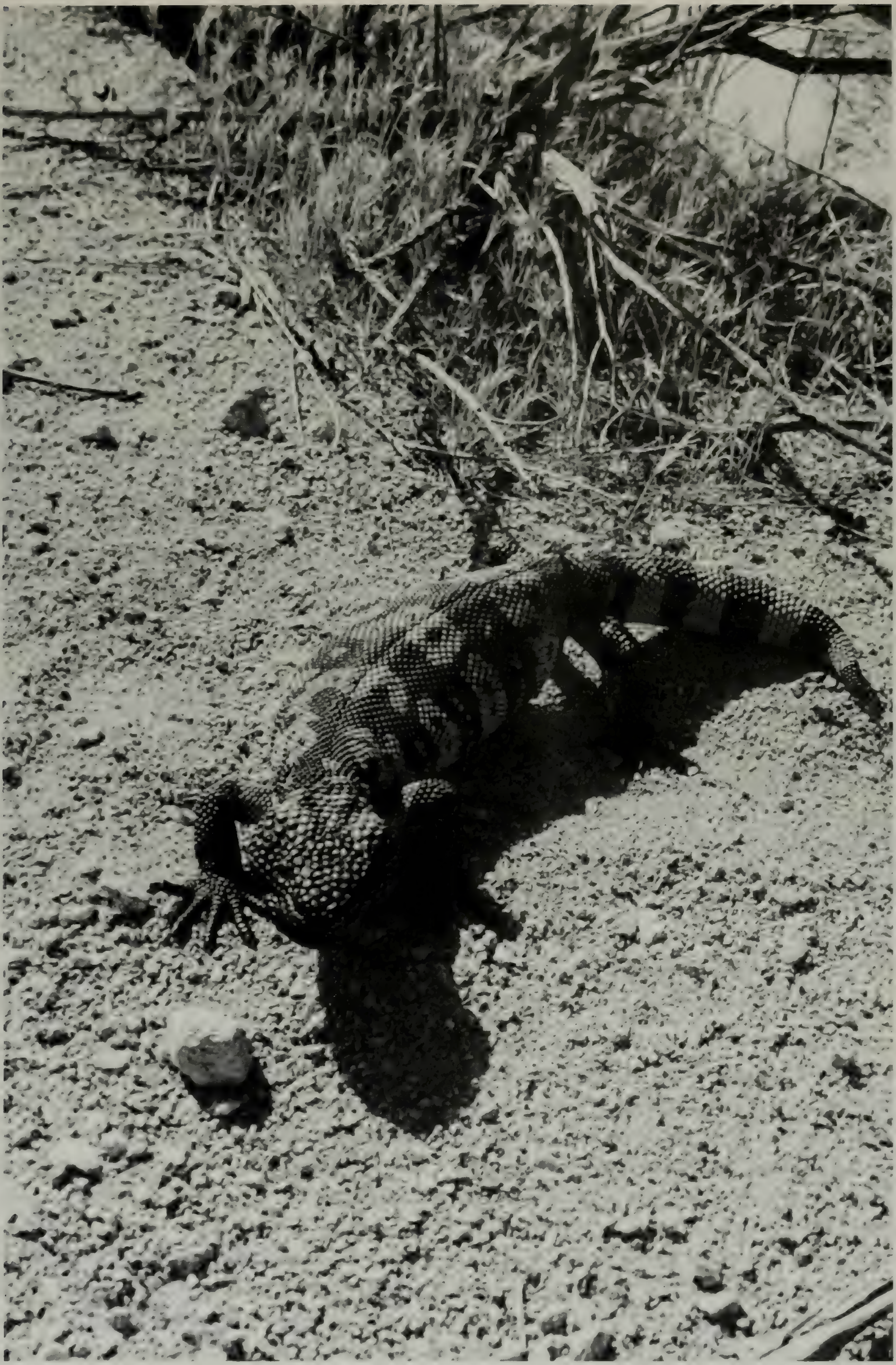

Fig. 7. Gila monster from the Kingston Range, San Bernardino County, California, 1.4 km west Porcupine Flats. Photo by Randall Ford, 30 May, 1980. LACMPC #1330.

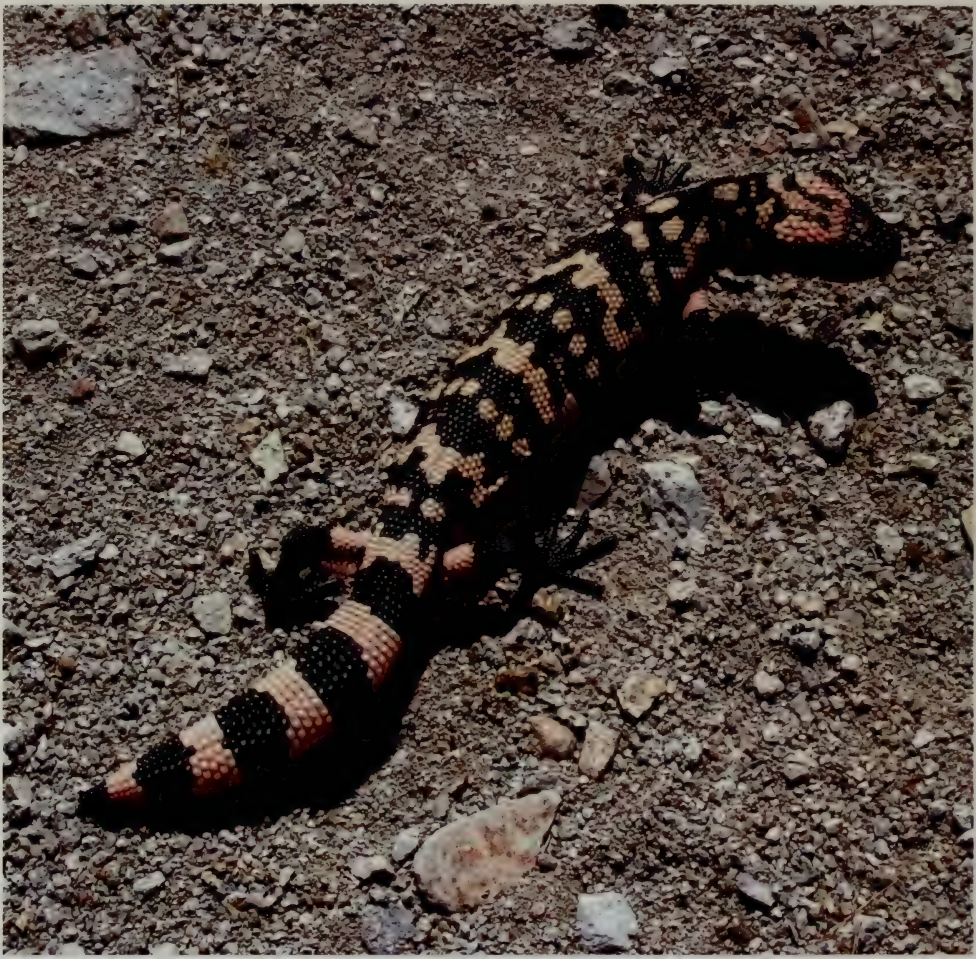

Fig. 8. Gila monster from the Kingston Range, San Bernardino County, California. Details of the sighting will be reported elsewhere. Photo by R. Terry Basey, 22 May, 2006. LACMPC #1439.

been reported from California. Although many are unverified or unsubstantiated by photographs or voucher specimens, they are listed here to stimulate additional searches for this elusive species. Some of the records of Gila monsters in California are undoubtedly for released captives, like the two specimens listed from urban Contra Costa County by Bury and Luckenbach (1976), an area well outside of the natural historic range of the species. However, translocated specimens have turned up in remote portions of the California desert as well. According to Brown (1976), a specimen was reported from the OX Ranch, Lanfair Valley, San Bernardino County in June, 1975. Apparently, the animal was a captive brought from Arizona by a ranch hand. That specimen is now housed at Museum of Vertebrate Zoology, U.C. Berkeley (MVZ 128983), after reportedly being won in a card game by California herpetologist Roger Luckenbach (Harry Greene, *in litt.*).

On April 8, 1999, a Gila monster was seen in the Cadiz Valley of San Bernardino County near Iron Mountain (T1N, R16E, Sec. 19). The sighting occurred at 0730 hr on a dirt road as an archaeologist was working on a project in the

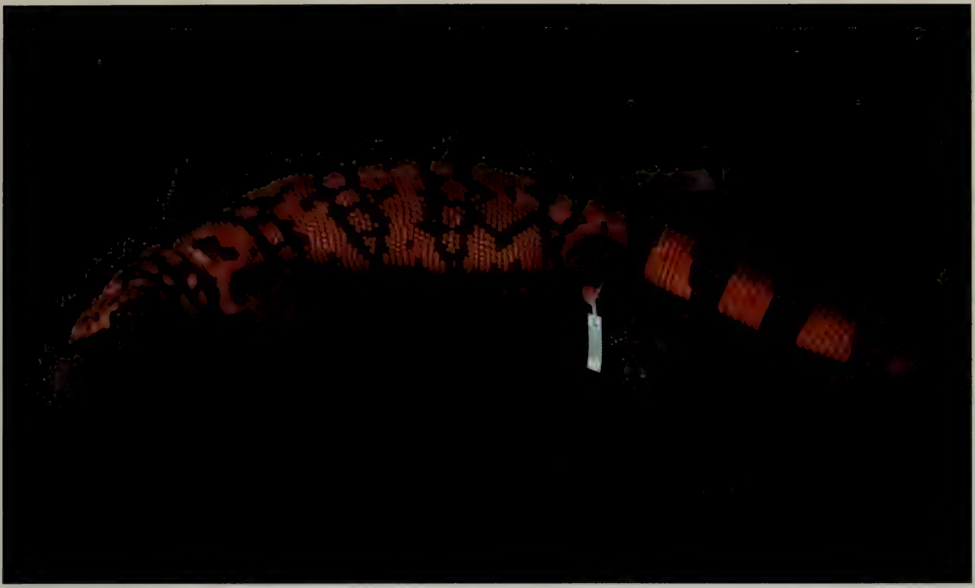

Fig. 9. Gila monster from Clark Mountain, San Bernardino County, California. Marjorie Barrick Museum of Natural History, University of Nevada, Las Vegas #R665.

area. The individual that discovered the animal was familiar with Gila monsters and was certain of the identity of the specimen. No photographs were taken. The relatively populated nature of the area to the west of this locale suggests the possibility that the specimen was a released captive. Furthermore, the area appears to be atypical of habitats where other Gila monsters have been observed in California (with the possible exception of the Colorado Desert records near Blythe and Desert Center), casting some doubt on the probability that it was indigenous.

Other Gila monsters have been reported from the area around Barstow, California, lending further credence to their occurrence along the Mojave River as discussed previously. In a letter to one of the authors (KRB), Steve Smith reported the following newspaper article published in the Barstow Printer Review on 5 June, 1958, page 9:

> *Persistent reports that Gila monsters are invading California were lent a little more credence this past week by the shooting of a lizard closely resembling the description of the poisonous Gila of Arizona by Mrs. John Sturnacle of Barstow. Reports of Gila monsters recently on the slopes of Mt. General near Hinkley and through the Calicos, have been discounted in the past. The beaded lizard, believed to be the only poisonous lizard in the United States, has been considered to be a denizen of Arizona and never found in California. A second sighting of a large lizard with a blunt tail, and whose hide displayed a beaded appearance and was ringed with red and cream bands, took place in the sand hills north of Hinckley Sunday. The lizard hissed characteristically when disturbed, and scuttled off down a dry wash. The 17-inch lizard shot by Mrs. Sturnacle was exhibited at the meeting of Cub Scout pack 68 on May 28, and taken to school to show the second graders at Cameron. Mrs. Sturnacle was moved to shoot the reptile when her small son*

> *chased it across the yard. He was deterred from picking the lizard up by his sister Deloris Ann, who is a second grade pupil at Cameron. The California Department of Fish and Game has been queried to determine the advisability of warning parents of small children to watch for the big lizards.*

One specimen, catalogued by the California Academy of Sciences as #172 from "southern California" was lost in the earthquake and fire of 1906. No other data are associated with this specimen.

It is important to consider possible misidentifications of other lizard species when evaluating Gila monster records in California. Some recent records have doubtless been chuckwallas (*S. obesus*), or other species, including exotics. The Yuma Sun reported sightings of a large lizard along the Colorado River in an article from the 29 June, 2001 edition. The animal was photographed and determined to be a water monitor (*Varanus salvator*). We are aware of savanna monitor (*V. exanthematicus*) sightings in the California desert as well (Lovich, pers. obs.).

Discussion

That the Gila monster is a resident of California is now well-supported by as many as 26 records, from four counties, at no less than nine locations, during the last 153 years (Table 1). Additional support for their indigenous status is given by the fact that specimens for which good photographs or descriptions are available generally agree with the subspecies *Heloderma suspectum cinctum,* which is the race expected west of the Colorado River.

However, this conclusion was not reached without considerable disagreement and contradiction in the scientific literature. The earliest published record of Gila monsters in California we found was that of Baird (1859) for the Mojave River specimen described above. Cooper (1869) included the Gila monster in his list of species known from the desert region of California. In contrast, Van Denburgh (1897) only acknowledged the possibility they occurred in California in his statement that "*It may be that it occurs on portions of the deserts of southeastern California, but as yet no specimens from this area have found their way into museums.*"

Despite the lack of consensus, some of the earlier claims were no doubt repeated by other writers who included California in the range of the Gila monster (Vick 1902; Willey 1906; Douglas 1910). That was until 1949 when Woodson published his record from Blythe and concluded that the Gila monster was not indigenous to California. Even the famous California desert naturalist, Edmund Jaeger (1956), considered the Gila monster to be absent from the state's fauna because of a barrier effect from the Colorado River, and Bogert and Martín del Campo considered the Mojave River specimen in the Smithsonian (see above) as "doubtless in error". Stebbins (1954) did not include California in the range of the Gila monster until publication of the second edition of his well-known field guide (Stebbins 1985), and Tinkham (1971) doubted that there were authentic records for the state over 100 years after Baird's initial report. The uncertainty began to change in the 1970's and 1980's as additional sightings occurred and photographs were taken.

Almost everything we know about this species has been shrouded in mystery at one time or another (Brown and Carmony 1991), so it is no surprise that it took so long for the Gila monster to be accepted as a part of the fauna of California. Due to the paucity of records, we have only a rudimentary understanding of the Gila monster's habitat requirements and ecology in California in particular, and the Mojave Desert in general. Seven out of the nine records in Table 1 with month of capture occur in April or May suggesting that this is an important time for surface activity. A May record from nearby Clark County, Nevada, is consistent with this finding (Cowles and Bogert 1936). Beck (1990) conducted detailed ecological studies on Gila monsters in the Mojave Desert of southwestern Utah and observed that 64 percent of Gila monster activity occurred from April–July. Although the records are scattered for this species in California, common habitat themes are worth noting. Most observations have occurred in mountainous areas with rocky, incised topography, in large and relatively high ranges. Many are associated with riparian areas, including the lower Colorado River. Most records occur at moderate elevations, but range from near sea level to over 1,200 m.

De Lisle (1983) suggested that some combination of weather patterns influences when Gila monsters are seen in California. Looking at the years of sightings in Table 1, only 1964 and 1977 were El Niño years. Of the other sightings, three (1962, 1968, and 1982) preceded El Niño years, and three (1943, 1948, and 1999) followed El Niño years. The years around 1982 are of interest because that was the time period that De Lisle (1983) reported nine sightings in the Providence Mountains. Local weather conditions may have been responsible. To test De Lisle's weather pattern hypothesis, we examined long-term (1958–1996) precipitation records (Hereford and Longpré 1999) for Mitchell Caverns, in the heart of the Providence Mountains. The year 1982 was in the middle of an exceptionally wet period that lasted from 1978–1984 (see also Hereford et al., 2006). During the time from 1982–1983 the local area experienced an unusually high number of days with precipitation over the course of a year, and warm season precipitation (defined by Hereford and Longpré as 1 July–14 October) was notably high from 1982–1984. The percentage of annual precipitation falling during the warm season from 1958–1996 has a mean of 29% (SD = 17.8%). From 1982–1984 the percentage exceeded 43% with 1982 being almost one standard deviation above the long term mean. The connection between El Niño years and environmental responses is not always straightforward (Bowers, 2005) and additional analyses are needed to determine their effect on Gila monster activity.

The geographic distribution of records suggests that the species is confined to the eastern portions of the California desert, despite the fact that visually similar habitats occur in the central and western Mojave Desert, as well as the Colorado Desert. Records from the Providence Mountains, Clark Mountains and Kingston Range suggest that Gila monsters may be a relict species isolated on the flanks of Mojave sky islands as the regional climate changed following the end of the last Ice Age. The locations of fossil helodermatids reveal a much wider distribution in the past during the Late Eocene of France, and the late Paleocene (and possibly late Cretaceous) to Recent of North America (Pregill et al. 1986).

Early in the Holocene Epoch (11,000–8,000 years ago) pluvial lakes occupied much of what is now the Mojave Desert because of sustained higher and more seasonal precipitation than what now characterizes the region. The Gila monster may have been widely distributed in the Mojave and Colorado Deserts around this time as Pleistocene (Rancholabrean) fossils are known from Gypsum Cave in Clark County, Nevada (Brattstrom 1954), and a late Irvingtonian fossil of *Heloderma* spp. is known from Anza-Borrego Desert State Park (Gensler, 2001). Then, about 7,000 years ago, the climate became sharply dryer and hotter (Grayson 1993), and reliable summer precipitation became more confined to the eastern Mojave Desert. The range of Gila monsters in California may have expanded into areas with reliable summer precipitation, or contracted into them, depending on whether they were moving up from southern refugia in the Sonoran Desert, or had remained in the region during glacial periods of the Quaternary. Invasions northward out of the Sonoran Desert may have used the Colorado River riparian corridor to enter the Mojave Desert as suggested by Bradley and Deacon (1966). As the climate shifted toward hyper-xeric conditions (possibly exceeding modern conditions) in the late Holocene, Gila monsters were restricted to areas with significant summer precipitation, many of which occur at moderate elevations on large mountain ranges in the northeastern Mojave Desert. Thus, the current distribution of modern records for Gila monsters in California appears to reflect the remnants of a lower Colorado River invasion from the Sonoran Desert into topographical refugia in the northeastern Mojave Desert with climatic conditions suitable for the species.

Other reptile species that appear to be isolated as relict populations in the high ranges of the northeastern Mojave Desert (Stebbins 1995) include the ring-necked snake (*Diadophis punctatus*), western fence lizard (*Sceloporus occidentalis*), striped whipsnake (*Masticophis taeniatus*), Smith's black-headed snake (*Tantilla hobartsmithi*), Gilbert's skink (*Eumeces gilberti*), and Panamint alligator lizard (*Elgaria panamintina*). Relict mammal species in the northeastern Mojave sky islands include the gray wolf (*Canis lupus*), now extirpated (Schmidt 1991), and porcupine (*Erethizon dorsatum*) (Johnson et al. 1948).

The distribution of Gila monsters in California may be related to biphasic annual rainfall patterns (Beck 2005). The Sonoran Desert of Arizona, where the Gila monster is more common than elsewhere in the United States, is characterized by distinct periods of winter and summer rain. Mean summer precipitation accounts for 39.7% of the annual total for 16 locations in the western Arizona desert according to Rowlands (1995). The significance of summer precipitation in defining the climate space of the Gila monster was noted by Bogert and Martín del Campo (1956) who suggested that the perceived absence of Gila monsters in California was related to dry summers west of the Colorado River. Tinkham (1971) similarly noted the importance of summer rainfall in defining the range of the Gila monster, showing that the subspecies *H. s. cinctum* occupied a climate space with slightly more winter rainfall and lower temperatures relative to the nominate race. The need for summer and winter rainfall may be related to associated biphasic increases in bird and mammal prey abundance in the spring, and again after the onset of summer rains in southern Arizona and Sonora, Mexico (Brown and Carmony 1991). The small early August peak in seasonal activity observed by Beck (1990) for Gila monsters in southwestern Utah suggests that the species responds similarly in the Mojave Desert.

Rowlands (1995) summarized rainfall data from throughout the Mojave and Colorado Deserts of California. Plotting his data (Figure 10), after removing the high altitude record for the White Mountains, shows a strong correlation ($R^2 = 0.812$, $P < 0.001$) between longitude and the percentage of annual rainfall that

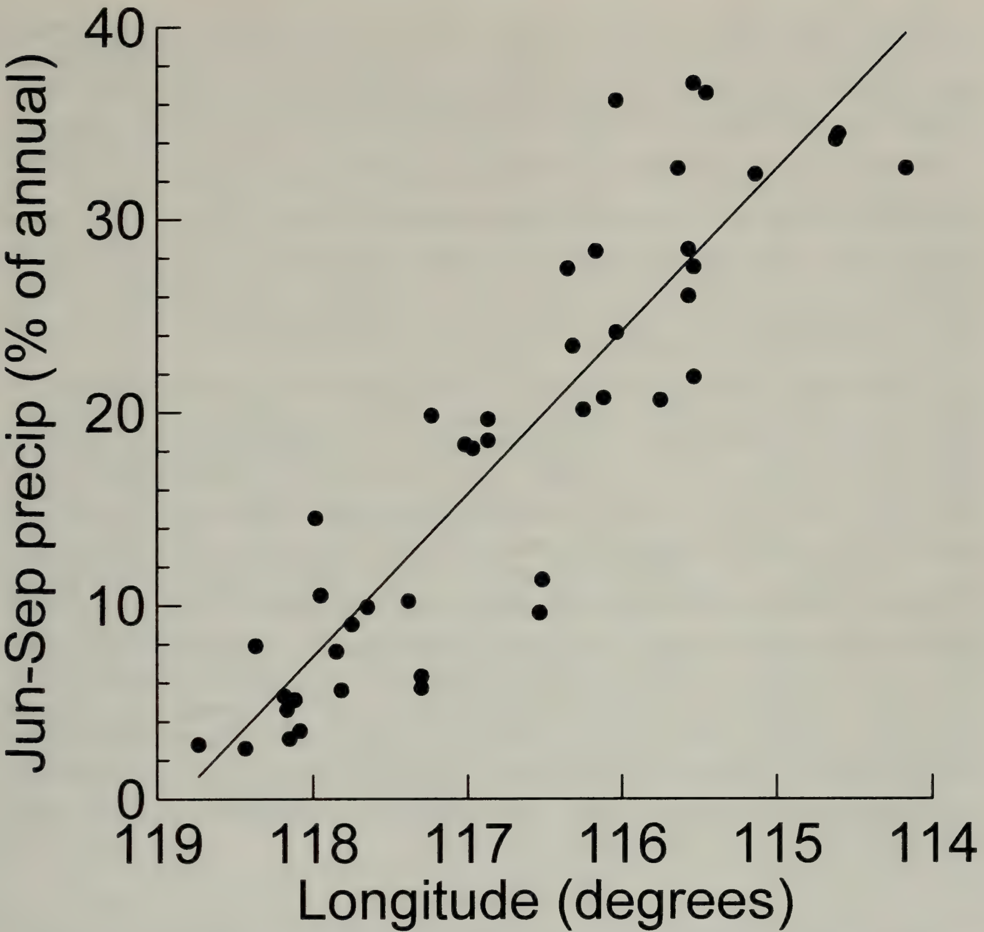

Fig. 10. The relationship between longitude (x-axis from west to east) and the percentage of annual rainfall occurring in the months from June–September in the Mojave and Colorado Deserts, California. From Rowlands (1995) but does not include the high altitude White Mountains record. Data are from the U.S. Department of Commerce, Weather Bureau (1945–75, 1952, 1958, 1964 [sic]).

occurs in the summer (defined by Rowlands as June–September). All known Gila monster records in California occur east of about 116° longitude, except for the specimen from the Mojave River. According to the relationship portrayed in Figure 10, this corresponds to areas receiving greater than 24% of the total annual precipitation between June and September. Using Rowland's data, and selecting the recording stations closest to the Gila monster records listed in Table 1 (Eagle Mountain – 36.5%, Imperial – 26%, Blythe – 34.4%, Iron Mountain – 32.3%, Mitchell Caverns – 27.5%, Mountain Pass – 37.0%, Needles – 34.1%) shows that the mean summer precipitation at these locales account for 32.5 percent of the annual total, which is close to the mean value of 39.7% for western Arizona reported above (Rowlands 1995). Beck (2005) reported that Gila monsters are "conspicuously absent" from areas where summer precipitation is less than 25% of annual precipitation, which fits our model of distribution in the Mojave Desert of California very well.

The absence of Gila monster records in other large mountain systems west of 116° longitude (San Bernardino, Little San Bernardino, Santa Rosa, San Jacinto, and Avawatz Mountains, and the Panamint and Coso Ranges, to name but a few) supports the presumed importance of summer rainfall to California Gila monsters, a finding that was echoed by Ford (1983). However, if this scenario is correct, why haven't Gila monsters been recorded from some sky islands east of 116° longitude such as the Granite Mountains adjacent to the Providence Mountains? The Granites and other significant mountain ranges east of 116° longitude in California (the Whipple Mountains, Turtle Mountains, and Chemehuevi Mountains) were suggested by Brown and Carmony (1991) as areas where surveys for this species should be intensified.

Conservation of the Gila monster in California requires an understanding of the factors defining its rarity along with the interaction of historical and climatic factors. It is likely that the Gila monster was rare in California long before the arrival of Europeans due to climatic changes and the marginal location of the state in the range of this species. The current restriction of the range to areas east of 116° longitude provides a focal area for conservation efforts. Fortunately, this part of California, often referred to as the "Lonesome Triangle," is still largely undisturbed (but see Lovich and Bainbridge 1999), and much of the Gila monster habitat therein is protected in designated wilderness areas or the Mojave National Preserve. However, the small population size of Gila monsters in California presents special challenges, including the Allee effect, loss of genetic diversity, and inbreeding (Meyers 1997), that are not easy to manage and increase the risk of local or regional extirpation. Recognition of these challenges will be required to maintain the elusive and enigmatic Gila monster as a viable part of California's exceptionally diverse biota (Meyers et al., 2000).

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Literature Cited

Baird, S.F. 1859. Report upon the reptiles of the route. In, Reports of the Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean. Route near the thirty-fifth parallel, Explored by Lieutenant A.W. Whipple. Washington, D.C. Vol. 10, pt. 6, no 4, pp. 37–45, pls. 25–27.

Beaman, K.R., D.D. Beck and B.M. McGurty. 2006. The beaded lizard (*Heloderma horridum*) and Gila monster (*Heloderma suspectum*): A bibliography of the family Helodermatidae. Smith. Herpetol. Info. Serv. No. 135:1–66.

Beck, D.D. 1990. Ecology and behavior of the Gila monster in southwestern Utah. J. Herpetol. 24: 54–68.

Beck, D.D. 2005. Biology of Gila monsters and beaded lizards. University of California Press, Berkeley. 247 pp.

Bicket, J.C. 1982. *Heloderma suspectum cinctum* (banded Gila monster). Geographic Distribution. Herpetol. Rev. 13:131.

Bogert, C.M. and R. Martin del Campo. 1956. The Gila monster and its allies: the relationships, habits, and behavior of the lizards of the family Helodermatidae. Bull. Am. Mus. Nat. Hist. 109:242 pp.

Bowers, J.E. 2005. El Niño and displays of spring-flowering annuals in the Mojave and Sonoran deserts. J. Torrey Bot. Soc. 132:38–49.

Bradley, W.G. and J. E. Deacon. 1966. Distribution of the Gila monster in the northern Mojave Desert. Copeia 1966:365–366.

Brattstrom, B.H. 1954. Amphibians and reptiles from Gypsum Cave, Nevada. Bull. So. California Acad. Sci. 53:8–12.

Brown, T.W. 1976. A herpetofaunal survey of the Mojave Desert of eastern San Bernardino County, California. Contract Report for U.S. Department of the Interior, Bureau of Land Management, California Desert District Office, Riverside. In, Berry, K.H., E. Wessman, and J. Aardahl. 1976. Unit resource analysis for East Mojave Planning Unit: wildlife (fish, amphibians, reptiles, and mammals). U.S. Department of the Interior, Bureau of Land Management, California Desert Program, Riverside, California. Draft report. 151 pp.

Brown, D.E. and N.B. Carmony. 1991. Gila monster: facts and folklore of America's Aztec lizard. High Lonesome Books, Silver City, New Mexico. 130 pp.

Burk, J. H. 1977. Sonoran Desert. Pp. 869–889 in Terrestrial Vegetation of California (M. G. Barbour and J. Major, eds.), John Wiley and Sons, New York, 1014 pp.

Bury, R.B. and R.A. Luckenbach. 1976. Introduced amphibians and reptiles in California. Biol. Cons. 10:1–14.

Cooper, J.G. 1869. The fauna of California and its geographical distribution. Proc. California Acad. Sci. Ser. 1:61–81.

Cowles, R.B. and C.M. Bogert. 1936. The herpetology of the Boulder Dam region (Nev., Ariz., Utah). Herpetologica 1:33–42.

De Lisle, H.F. 1979. Gila monster (*Heloderma suspectum*) found in California. Herpetology (Southwestern Herpetologist's Society) 10:5–7.

De Lisle, H.F. 1983. Banner year for California Gilas. Herpetology (Southwestern Herpetologist's Society) 13:11.

De Lisle, H.F. 1986. The biology of the Gila monster. Herpetology (Southwestern Herpetologist's Society). 15:1–28.

Douglas, E. 1910. The Gila monster, a convicted suspect. Arizona (Magazine). December: 9–10.

Ford, R.S. 1981. *Heloderma suspectum cinctum* (banded Gila monster). Geographic Distribution. Herpetol. Rev. 12:64.

Ford, R.S. 1983. Reptiles and amphibians. Pp. 123–130 in The Kingston Range of California: a resource survey. (R.D. Stone and V.A. Sumida, eds.), Publication No. 10, Environmental Field Program, University of California, Santa Cruz.

Funk, R.S. 1966. Notes about *Heloderma suspectum* along the western extremity of its range. Herpetologica 22:254–258.

Gensler, P.A. 2001. The first fossil *Heloderma* from the mid-Pleistocence (Late Irvingtonian) Coyote Badlands, Anza-Borrego Desert State Park®, southern California. P. 71 in The Changing face of the east Mojave Desert. Abstracts of the 2001 Desert Symposium. (R.E. Reynolds, ed.), Desert Studies Center, California State University.

Grayson, D. K. 1993. The desert's past: a natural prehistory of the Great Basin. Washington, D.C. Smithsonian Institution Press. 356 pp.

Hazard, L. and J. T. Rotenberry. 1996. Herpetofauna and vegetation survey of Cornfield Spring and Piute Spring, east Mojave Desert, California. Pp. 69–73 in Proc. East Mojave Desert Symp. 7–8 November 1992, University of California, Riverside. (C. Luke, J. André, and M. Herring, eds.), Nat. Hist. Mus. Los Angeles County Tech. Rept. No. 10. 164 pp.

Hereford, R. & Longpré, C. (1999). Climate history of the Mojave Desert Region, 1892–1996, including data from 48 long-term weather stations and an overview of regional climate variation. Web Page: http://mojave.usgs.gov/climate-history/statimage.html

Hereford, R., R.H. Webb, and C.I. Longpré. 2006. Precipitation history and ecosystem response to multidecadal precipitation variability in the Mojave Desert Region, 1893–2001. J. Arid. Environ. 67:13–34.

Jaeger, E.C. 1956. On desert trails with a naturalist. XXVII: last stand of the pronghorn. The Desert Magazine 19:17–18.

Jennings, M. R. and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. California Department of Fish and Game, Rancho Cordova, California. 255 pp.

Johnson, D.H., M.D. Bryant, and A.H. Miller. 1948. Vertebrate animals of the Providence Mountains area of California. Univ. California Press, Berkeley. 375 pp.

Lovich, J. E. and D. Bainbridge. 1999. Anthropogenic degradation of the southern California desert ecosystem and prospects for natural recovery and restoration. Environ. Mgmt. 24:309–326.

Lovich, J.E. and K.P. Meyer. 2002. The western pond turtle (*Clemmys marmorata*) in the Mojave River, California, USA: highly adapted survivor or tenuous relict? J. Zool., London 256:537–545.

Meyers, N. 1997. Global biodiversity II: losses and threats. Pp. 123–158 in Principles of Conservation Biology. (G.K. Meffe and C. R. Carroll, eds.). Sinauer Assoc., Inc. Sunderland, Massachusetts. 729 pp.

Meyers, N., R.A. Mittermeier, C.G. Mittermeier, G.A.B. Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853–845.

Mitchell, J. V. 1978. Composition and abundance of reptiles and amphibians of the Clark Mountain area San Bernardino County, California May 1978–September 1978. Contr. Rep. CA-060-CT8-000043 to Bureau of Land Management, Riverside, California. 34 pp.

Montanucci, R.R. 2001. A clarification of the type locality and collector of the holotype of *Sauromalus obesus* (Baird) 1858. Herpetol. Rev. 32:17–20.

Pregill, G.K., J.A. Gauthier, and H.W. Greene, 1986. The evolution of helodermatid squamates, with descriptions of a new taxon and an overview of the Varanoidea. Trans. San Diego Soc. Nat. Hist. 21(11):167–202.

Rowlands, P.G. 1995. Regional bioclimatology of the California desert. Pp. 95–134 in The California Desert: an introduction to natural resources and man's impact. Vol. I. (J. Latting and P.G. Rowlands, eds.). June Latting Books. Printed and bound by the Univ. California, Riverside Press.

Schmidt, R. H. 1991. Gray wolves in California: their presence and absence. California Fish and Game. 77(2):79–85.

Stebbins, R.C. 1954. Amphibians and reptiles of western North America. McGraw-Hill Book Co., Inc. New York. 536 pp.

Stebbins, R.C. 1985. Western reptiles and amphibians. Houghton Mifflin Co., Boston. 336 pp.

Stebbins, R.C. 1995. Desert reptiles. Pp. 317–336 in The California Desert: an introduction to natural resources and man's impact. Vol. II. (J. Latting and P.G. Rowlands, eds.). June Latting Books. Printed and bound by the University of California, Riverside Press.

Stejneger, L. 1893. Annotated list of the reptiles and batrachians collected by the Death Valley Expedition in 1891, with descriptions of new species. N. Amer. Fauna 7:159–228.

Stone, R.D. and V.A. Sumida (eds.). 1983. The Kingston Range of California: a resource survey. Publication No. 10, Environmental Field Program, University of California, Santa Cruz.

Tinkham, E.R. 1971. The biology of the Gila monster. Pp. 387–421 in Venomous animals and their venoms. (W. Bücherl, and E.E. Buckley, eds.). Academic Press, New York. 687 pp.

Vasek, F. C. and M. G. Barbour. 1977. Mojave Desert scrub vegetation. Pp 835–867 in Terrestrial Vegetation of California. (M. G. Barbour and J. Major, eds.), John Wiley and Sons, New York.

Van Denburgh, J. 1897. The reptiles of the Pacific coast and Great Basin: an account of the species known to inhabit California, Oregon, Washington, Idaho and Nevada. Occ. Paps. California Acad. Sci. (5):1–235.

Vick, E.C. 1902. The Gila monster. Country Life in America. January: 102.

Willey, D.A. 1906. Gila monsters. Scientific American 95:192.

Woodson, W.D. 1949. Gila monster in California? Herpetologica 5:151.

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2004 Annual Meeting
California State University
Fullerton, California

June 1–2, 2007

ABSTRACTS OF PAPERS

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2008—California State University, Dominguez Hills

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In addition, special thanks to **Andrea Murray**, whose work arranging facilities at CSU Fullerton was instrumental in our preparation for this meeting.

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Student Award Categories = E: Ecology & Evolution; F: Fishery Biology; M: Molecular Biology & Physiology; P= Physical Science

Friday, June 1, 2007
Location: ONTIVEROS

Session: Aquatic Invasive Species

Chair: Sabrina Drill, University of California Cooperative Extension

1 8:40 **TROUBLED WATERS: THE BIOLOGICAL INVASION OF SOUTHERN CALIFORNIA WATERWAYS.**
Louanne McMartin. Non-native Invasive Species Program, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Stockton, CA 95205.

2 9:00 **THE INVASIVE *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) IN CALIFORNIA WITH DATA FROM THE UPPER OWENS RIVER WATERSHED.**
G.K. Noda. University of California, Los Angeles, Department of Ecology and Evolutionary Biology, Box 951606, 621 Charles E. Young Dr. South, Los Angeles, CA 90095.

3 9:20 **MUDSNAILS INVADE THE 'BU: A CASE STUDY IN INSTITUTIONAL RESPONSES TO INVASIONS.**
D. M. Tamanaha and J. R Topel. Santa Monica Bay Restoration Commission, 320 West 4th St., Suite 200, Los Angeles, CA 90013.

4 9:40 **DEVELOPMENT OF BIOLOGICAL CONTROL FOR THE NEW ZEALAND MUD SNAIL.**
T. Dudley[1], K.D. Lafferty[2,1], **B.L. Fredensborg**[1], and A.M. Kuris[3,1]. [1]Marine Science Institute; [3] Department of Ecology, Evolution, and Marine Biology; [2]US Geological Survey, Western Ecological Research Center; [1,2,3]University of California, Santa Barbara, CA 93106.

5 10:00 **EFFECTS OF URBANIZATION ON THE DISTRIBUTION AND ABUNDANCE OF AMPHIBIANS AND INVASIVE SPECIES IN SOUTHERN CALIFORNIA STREAMS.**
Seth P. D. Riley[1], **Gary T. Busteed**[1], Lee B. Kats[2], Thomas L. Vandergon[2], Lena F. S. Lee[1], Rosi G. Dagit[3], Jacob L. Kerby[1,3,5], Robert N. Fisher[4], and Raymond M. Sauvajot[1]. [1]Santa Monica Mountains National Recreation Area, National Park Service, 401 W. Hillcrest Dr., Thousand Oaks, CA 91360; [2]Department of Biology, Pepperdine University, 24255 Pacific Coast Highway, Malibu, CA 90263; [3]Resource Conservation District of the Santa Monica Mountains, 122 N. Topanga Canyon Blvd., Topanga, CA 90290; [4]U.S. Geological Survey, San Diego Field Station, 5745 Kearny Villa Drive, Suite M, San Diego, CA 92123; [5]Environmental Science and Policy, 1 Shields Ave., University of California, Davis, CA 95616.

6 E 10:20 **AMPHIBIAN LIFE IN RESPONSE TO THE ACTIVE REMOVAL OF EXOTIC SPECIES IN STREAMS OF THE SANTA MONICA MOUNTAINS.**
L. Kats, S. Rollert, T. Thurling, **S. Landis**, and D. Cho. Pepperdine University, Department of Biology and Behavioral Ecology, Malibu, CA 90263.

10:40–11:00 **BREAK**

7 11:00 **CALIFORNIA RESPONSE TO THE DISCOVERY OF QUAGGA MUSSEL/ZEBRA MUSSEL IN LAKE MEAD.**
S.R. Ellis. California Department of Fish and Game, Habitat Conservation Branch, Sacramento, CA 95814.

8 E 11:20 **DISTRIBUTION, HABITAT UTILIZATION, AND REPRODUCTIVE PATTERNS IN *CAULACANTHUS USTULATUS* (CAULACANTHACEAE, GIGARTINALES), A NEWLY ESTABLISHED SEAWEED ON SOUTHERN CALIFORNIA SHORES.**
K.E. Whiteside, J.R. Smith, and S. N. Murray. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92834.

9 11:40 **MANAGING THE SPREAD OF AQUATIC NUISANCE SPECIES THROUGH HACCP PLANNING.**
Denise A. Walther. Non-native Invasive Species Program, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Stockton, CA 95205.

12:00–1:20 **LUNCH BREAK**

Friday, June 1, 2007
Location: ONTIVEROS

Session: Ecological, Environmental and Evolutionary Parasitology

Chair: Donald G. Buth, University of California, Los Angeles

1:20 **Introduction, Donald G. Buth**

10 1:25 **PARASITES IN FOOD WEBS AS BIOINDICATORS OF ENVIRONMENTAL CONDITIONS.**
Kevin D. Lafferty. University of California, Santa Barbara, CA 93106.

11 2:00 **RELATIONSHIPS BETWEEN ENDOHELMINTH ASSEMBLAGES OF FISH AND WATER QUALITY.**
C. Hogue. California State University, Northridge, Department of Biology, Northridge, CA 91330.

12 2:20 **THE BIOMASS OF PARASITES AND THE ENERGETICS OF ECOSYSTEMS.**
Armand M. Kuris. University of California, Santa Barbara, CA 93106.

13 2:40 **FISH PREDATION ON TREMATODE CERCARIAE IN A CALIFORNIA ESTUARY.**
Amber T. Kaplan, Sayward E. Halling, Kevin D. Lafferty, and Armand M. Kuris. University of California, Santa Barbara, CA 93106.

3:00–3:20 **BREAK**

14 3:20 **DEVELOPMENT OF *ASCAROPHIS* SP. (NEMATODA: CYSTIDICOLIDAE) TO MATURITY IN *GAMMARUS DEUBENI* (AMPHIPODA).**
R.G. Appy. Port of Los Angeles, Environmental Management Division, San Pedro, CA 90371.

15 3:40 **PARASITE MANIPULATION OF BRAIN MONOAMINES IN KILLIFISH.**
J.C. Shaw[1], W. J. Korzan[2], R. E. Carpenter[3,4], A. M. Kuris[1], K. D. Lafferty[5], C. H. Summers[3,4], and Ø. Øverli[3,4,6]. [1]Department of Ecology, Evolution and Marine Biology, University of California Santa Barbara, CA; [2]Stanford University, Stanford, CA; [3]Biology; [4]Neuroscience Group, Division of Basic Biomedical Sciences, University of South Dakota, Vermillion, SD; [5]USGS, University of California Santa Barbara, CA; [6]Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, N-1432 Aas, Norway.

16 4:00 **THE INFLUENCE OF ECTOPARASITES AND WASTEWATER DISCHARGE ON THE ENDOCRINE STRESS RESPONSE IN MARINE FISHES.**
J.E. Kalman, **J.A. Reyes**, J.L. Armstrong, K. Sak, and K.M. Kelley. California State University, Long Beach, CA; Orange County Sanitation District, Fountain Valley, CA.

17 M 4:20 **THE EFFECTS OF THE ECTOPARASITIC ISOPOD *ELTHUSA CALIFORNICA* ON THE RESPIRATION OF THE SURF PERCH *CYMATOGASTER AGGREGATA***
H.D. Johnston, E. Guirges, and E.N. Kageno. University of California, Los Angeles, Department of Evolutionary and Ecological Biology, Los Angeles, CA 90024.

5:00–6:45 **Poster Session and Wine & Cheese Social**. *Courtyard.*

7:00–8:00 **Plenary Lecture**. *Portola Pavilions A & B.*
Dr. Francisco J. Ayala, Donald Bren Professor of Biological Sciences, University of California, Irvine.

DARWIN AND INTELLIGENT DESIGN

8:00–9:00 **Book-Signing Reception**. *Chapman Atrium.*

Friday, June 1, 2007
Location: HETEBRINK

Session: On-Going Paleoenvironmental Studies from Southern California and Surrounding Regions

Chair: Matthew E. Kirby, California State University, Fullerton

18 P 8:40 **HISTORIC MERCURY DEPOSITION WITHIN THREE SOUTHERN CALIFORNIA SITES.**
Sarah E. Rothenberg[1], Matthew E. Kirby[2], and Jennifer A. Jay[3]. [1]Environmental Science and Engineering Program, Box 951772 CHS, University of California, Los Angeles, CA 90095; [2]Department of Geological Sciences, California State University, Fullerton, CA 92834; [3]Department of Civil and Environmental Engineering, Box 951593 Boelter Hall, University of California, Los Angeles, CA 90095.

19 P 9:00 **HIGH-RESOLUTION THIN-SECTION PHOTOMICROGRAPHY ANALYSIS OF A GLACIAL-AGE SEDIMENT CORE FROM BALDWIN LAKE, SOUTHERN CALIFORNIA: A LOOK AT SOME INITIAL RESULTS.**
Michael Blazevic, Matthew Kirby, Adam Woods, Brandon Browne, and Dave Bowman. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92831.

20 9:20 **THE PALEOENVIRONMENT OF BURGESS SHALE-TYPE DEPOSITS: FROM SOUTHERN CALIFORNIA TO SOUTH CHINA.**
R.R. Gaines. Pomona College, Geology Department, Claremont, CA 91711.

21 9:40 **LATE QUATERNARY VEGETATION HISTORY OF THE MOJAVE-COLORADO DESERT ECOTONE AT JOSHUA TREE NATIONAL PARK**
C.A. Holmgren[1], J.L. Betancourt[2], and K.A. Rylander[2]. [1]California State University, Long Beach, Department of Geography, Long Beach, CA 90840; [2]U.S. Geological Survey, 1675 W. Anklam Rd., Tucson, AZ 85745.

22 10:00 **CONTEMPORARY WATER QUALITY AND SEDIMENT PROPERTIES OF SOUTHERN CALIFORNIA LAKES.**
M.A. Anderson. University of California, Department of Environmental Sciences, Riverside, CA 92521.

23 10:20 **FLOODS, FIRES, AND HUMANS: ASSESSING 150 YEARS OF RAPID DEPOSITIONAL EVENTS IN A SMALL ALPINE LAKE, SOUTHERN CALIFORNIA.**
M.E. Kirby[1], M.B. DeRose[1], and B.W. Bird[2]. [1]California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92834; [2]University of Pittsburgh, Department of Earth Sciences, Pittsburgh, PA.

10:40–11:00 **BREAK**

24 11:00 **RECONSTRUCTING LATE PLIOCENE TO MIDDLE PLEISTOCENE DEATH VALLEY LAKES AND RIVER SYSTEMS AS A TEST OF PUPFISH (CYPRINODONTIDAE) DISPERSAL HYPOTHESES.**
Jeffrey R. Knott. Department of Geological Sciences, California State University, Fullerton, CA 92834.

25 11:20 **ON-GOING PALEOENVIRONMENTAL STUDIES ON LAKES FROM CENTRAL CALIFORNIA.**
R. Negrini[1], D. Baron[1], M. Palacios-Fest[1], P. Wigand[1], K. O'Sullivan[1], J. Oseguera[1], Ben Fleming[1], Carol Register[1], Elizabeth Powers[1], Jason Leiran[1], Randall Stephenson[1], Adam Johnson[2], Lisa Pratt[2], and Dallas Rhodes[3]. [1]California State University, Bakersfield, CA 93301; [2]Indiana University, Bloomington, Indiana 47405; [3]Georgia Southern University, Statesboro, GA 30460.

26 11:40 **LATE PLEISTOCENE PLUVIAL LAKES OF THE OWENS RIVER CASCADE, CALIFORNIA: THE RELATIVE ROLES OF TECTONIC AND CLIMATIC FORCING.**
Antony R. Orme[1] and Amalie Jo Orme[2]. [1]Department of Geography, University of California, Los Angeles, CA 90095; [2]Department of Geography, California State University, Northridge, CA 91330.

12:00–1:20 **LUNCH BREAK**

Friday, June 1, 2007
Location: HETEBRINK

Session: Prehistoric and Historic Impacts on the Environment

Chair: Steven R. James and Edgar Huerta, California State University, Fullerton

1:20 **INTRODUCTION: PREHISTORIC AND HISTORIC ENVIRONMENTAL IMPACTS.**
S.R. James. Department of Anthropology, California State University, Fullerton, P.O. Box 6846, Fullerton, CA 92834.

27 1:40 **LATE PREHISTORIC HUMAN IMPACTS ON MARINE FAUNA IN SOUTHERN CALIFORNIA: AN EXAMPLE FROM SAN NICOLAS ISLAND IN THE SOUTHERN CHANNEL ISLANDS.**
S. R. James. Department of Anthropology, California State University, Fullerton, P.O. Box 6846, Fullerton, CA 92834.

28 2:00 **PREHISTORIC MARINE ADAPTATION AND POSSIBLE TRENDS OF OVEREXPLOITATION ON SAN NICOLAS ISLAND.**
James Wallace. Department of Anthropology, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831.

29 2:20 **FIXING THE LANDSCAPE IN PLACE: TAKIC PLACE NAMES AND NATURAL RESOURCES.**
Stephen O'Neil. SWCA Environmental Consultants, 23392 Madera, Suite L, Mission Viejo, CA 92691.

30 2:40 **BURIED SITES ARCHAEOLOGY: LIFE BY THE LAKES IN LAGUNA CANYON DURING THE INTERMEDIATE AND LATE PREHISTORIC PERIODS.**
Roderic N. McLean. LSA Associates, Inc., 20 Executive Park, Suite 200, Irvine, CA 92614.

3:00–3:20 **BREAK**

31 3:20 **PREHISTORIC AND HISTORICAL ENVIRONMENT INTERACTIONS ALONG SANTA MONICA BAY, CALIFORNIA.**
John G. Douglass, Richard Ciolek-Torrello, Benjamin Vargas, Seetha Reddy, Sarah Van Galder, Anne Stoll, and Donn Grenda. Statistical Research, Inc., 21 West Stuart Ave., Redlands, CA 92373.

32 3:40 UNDERSTANDING HUMAN RELATIONSHIPS WITH THE ENVIRONMENT THROUGH THE ANALYSIS OF ECONOMIC SYSTEMS DURING THE MIDDLE HOLOCENE IN THE NEWPORT BAY REGION.
Edgar Huerta. Department of Anthropology, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92831.

33 E 4:00 TAPHONOMIC IMPLICATIONS OF DIFFERENTIAL PRESERVATION BETWEEN FRESHWATER FISHES.
John Hash. California State University Bakersfield, Department of Biology, Bakersfield, CA 93311.

5:00–6:45 **Poster Session and Wine & Cheese Social**. *Courtyard.*

7:00–8:00 **Plenary Lecture**. *Portola Pavilions A & B.*
Dr. Francisco J. Ayala, Donald Bren Professor of Biological Sciences, University of California, Irvine.

DARWIN AND INTELLIGENT DESIGN

8:00–9:00 **Book-Signing Reception**. *Chapman Atrium.*

Friday, June 1, 2007
Location: GABRIELINO

Session: Ecology, Oceanography and Human Impacts of the Southern California Bight

Chair: Jim Allen, Southern California Coastal Water Research Program (SCCWRP)

34 8:20 LONG-TERM ECOLOGY OF THE ICHTHYOFAUNA ADJACENT TO HUNTINGTON BEACH GENERATING STATION: A REVIEW OF ONCE THROUGH COOLING THEN AND NOW IN THE CONTEXT OF OCEANIC REGIME SHIFT.
E.F. Miller[1], D. Shane Beck[1], John Steinbeck[2], Ernesto Calix[2], Kevin T. Herbinson[3], and Patrick Tennant[4]. [1]MBC Applied Environmental Sciences, Costa Mesa, CA; [2]Tenera Environmental, San Luis Obispo, CA; [3]ACT Environmental, Inc., Laguna Hills, CA; [4]Southern California Edison, Rosemead, CA.

35 8:40 THE RECOVERING PACIFIC SARDINE (*SARDINOPS SAGAX*) POPULATION AS AN INDICATOR OF LINKAGE BETWEEN THE SOUTHERN CALIFORNIA BIGHT AND THE NORTH PACIFIC TRANSITION ZONE.
P. E. Smith. Integrative Oceanography Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92037.

36 9:00 CHLORINATED HYDROCARBONS IN PELAGIC FORAGE FISHES AND SQUID OF THE SOUTHERN CALIFORNIA BIGHT.
Erica Jarvis, **Kenneth Schiff**, Lisa Sabin, and M. James Allen. Southern California Coastal Water Research Project, Costa Mesa, CA.

37 9:20 VARIATION IN DDT/PCB CONCENTRATIONS IN WHITE CROAKER (*GENYONEMUS LINIATUS*) IN THE SOUTHERN CALIFORNIA BIGHT: INFLUENES OF LOCATION, BODY SIZE, AND LIPID CONTENT.
D.A. Witting and G. Baker. NOAA Restoration Center, Long Beach, CA; NOAA Damage Assessment Center, Menlo Park, CA.

38 9:40 **CONDITION OF DEMERSAL FISH AND INVERTEBRATE ASSEMBLAGES IN THE SOUTHERN CALIFORNIA BIGHT IN 2003.**
M.J. Allen[1], T. Mikel[2], D. Cadien[3], J. E. Kalman[4], E. T. Jarvis[1], K. C. Schiff[1], D. W. Diehl[1], S. L. Moore[1], S. Walther[3], G. Deets[5], C. Cash[5], S. Watts[6], D. J. Pondella II[7], V. Raco-Rands[1], C. Thomas[4], R. Gartman[8], L. Sabin[1], W. Power[3], A. K. Groce[8], and J. L. Armstrong[4]. [1]Southern California Coastal Water Research Project, Costa Mesa, CA; [2]Aquatic Bioassay and Consulting Laboratory, Ventura, CA; [3]County Sanitation Districts of Los Angeles County, Whittier, CA; [4]Orange County Sanitation District, Fountain Valley, CA; [5]City of Los Angeles, Environmental Monitoring Division, Playa del Rey, CA; [6]Weston Solutions, Inc., Port Gamble Environmental Laboratories, Port Gamble, WA; [7]Occidental College Vantuna Research Group, Department of Biology, Los Angeles, CA; [8]City of San Diego, Metropolitan Wastewater Department, Marine Biology Laboratory, CA.

39 10:00 **THE CONDITION OF BENTHIC INVERTEBRATE COMMUNITIES IN THE SOUTHERN CALIFORNIA BIGHT.**
J.A. Ranasinghe[1], A.M. Barnett[1], K. Schiff[1], D.E. Montagne[2], C. Brantley[2], C. Beegan[3], D.B. Cadien[2], C. Cash[4], D.R. Diener[5], T.K. Mikel[6], R.W. Smith[7], R.G.Velarde[8], S.D. Watts[9], and S.B. Weisberg[1]. [1]Southern California Coastal Water Research Project, 3535 Harbor Blvd., Suite 110, Costa Mesa, CA 92626; [2]County Sanitation Districts of Los Angeles County, P.O. Box 4998, Whittier, CA 90607; [3]State Water Resources Control Board, Sacramento, CA; [4]City of Los Angeles, Environmental Monitoring Division, 12000 Vista Del Mar, Playa Del Rey, CA 90293; [5]P.O. Box 5196, Oceanside, CA 92052; [6]Aquatic Bioassay and Consulting Laboratories, Inc., 29 North Olive Street, Ventura, CA 93001; [7]Deceased; [8]City of San Diego Marine Biology Laboratory, 2392 Kincaid Rd., San Diego, CA 92101; [9]Weston Solutions, Port Gamble Environmental Laboratories, Port Gamble, WA 98364.

40 10:20 **CHARACTERISTICS OF BENTHIC MACROFAUNA OF THE SOUTHERN CALIFORNIA BIGHT.**
T.K. Mikel[1], Ananda Ranasinghe[2], and David E. Montagne[3]. [1]Aquatic Bioassay and Consulting Laboratories, Inc., 29 North Olive Street, Ventura, CA 93001; [2]Southern California Coastal Water Research Project, 3535 Harbor Blvd., Suite 110, Costa Mesa, CA 92626; [3]County Sanitation District of Los Angeles County, P.O. Box 4998, Whittier, CA 90607.

10:40–11:00 **BREAK**

41 11:00 **MARINE ECOLOGICAL MONITORING STUDIES AT CRYSTAL COVE STATE PARK TO DETERMINE IMPACTS FROM A COASTAL DEVELOPMENT PROJECT.**
R. F. Ford[1,2], **M. A. Shane**[2], and J. Kern[3]. [1]San Diego State University, Biology Department, San Diego, CA 92182; [2]Hubbs-Sea World Research Institute, 2595 Ingraham Street, San Diego, CA 92109; [3]Kern Statistical Services, Inc., 5175 NE River Road, Sauk Rapids, MN 56379.

42 11:20 **MODIS IMAGERY AS A TOOL FOR SYNOPTIC WATER QUALITY ASSESSMENTS IN SOUTHERN CALIFORNIA COASTAL OCEAN.**
Nikolay P. Nezlin[1], Paul M. DiGiacomo[2], Burton H. Jones[3], Kristen M. Reifel[3], Scott C. Johnson[4], Mike Mengel[5], and Jonathan A. Warrick[6]. [1]Southern California Coastal Water Research Project, Costa Mesa, CA 92626; [2]NOAA/NESDIS Center for Satellite Applications and Research (STAR), Camp Springs, MD 20746; [3]Department of Biological Sciences, University of Southern California, Los Angeles, CA 90089; [4]Aquatic Bioassay and Consulting Laboratories, Ventura, CA 93001; [5]Orange County Sanitation District (OCSD), Fountain Valley, CA 92728; [6]USGS Coastal and Marine Geology Program, Santa Cruz, CA 95060.

43 11:40 **SETTING UP A WATER QUALITY MONITORING NETWORK ALONG THE CALIFORNIA COASTLINE**
A.L. Willingham, L. Gilbane, R. Pieper, and A. Resister. Southern California Marine Institute, CICORE (Center for Integrative Coastal Observation Research and Education), San Pedro, CA 90731.

12:00–1:20 **LUNCH BREAK**

Friday, June 1, 2007
Location: BRADFORD

Session: Volcanism and Plutonism in the Southwestern U.S.

Chair: Brandon Browne, California State University, Fullerton

44 2:00 **CONTRASTING BASALTIC ERUPTION STYLES OBSERVED AT RED CONES, EASTERN SIERRA NEVADA.**
B.L. Browne, M. Louros, and A. Martos. California State University Fullerton, Department of Geological Sciences, Fullerton, CA 92834.

45 P 2:20 **PETROLOGIC CONSTRAINTS ON ERUPTION TRIGGERING AT MAMMOTH MOUNTAIN, CALIFORNIA.**
C. Terpolilli and B. Browne. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92834.

46 2:40 **U-PB DATING OF ZIRCON CRYSTALLIZATION IN THE HOT CREEK RHYOLITE, LONG VALLEY CALDERA, CALIFORNIA: NO CRYSTAL MEMORY OF BISHOP TUFF MAGMA.**
J.A. Vazquez and C. Gainer. Department of Geological Sciences, California State University, Northridge, CA 91330.

3:00–3:20 **BREAK**

3:20–4:30 THE FOLLOWING POSTERS RELATING TO THIS SESSION WILL BE PRESENTED BY THEIR AUTHORS. *Courtyard.*

47 **NEOGENE ALKALINE/SUBALKALINE VOLCANISM IN THE EASTERN MOJAVE PROVINCE.**
S.M. Baltzer and D.R. Jessey. Geological Sciences Department, California State Polytechnic University, Pomona, CA 91768.

48 P **VOLCANIC PETROLOGY, GEOCHEMISTRY AND STRATIGRAPHY OF THE GRANDE SOUFRIERE HILLS VOLCANO, DOMINICA, WEST INDIES.**
G.E. Daly and A.L. Smith. California State University, San Bernardino, Department of Geological Sciences, San Bernardino, CA 92407.

49 P **PALEOMAGNETIC EVIDENCE FOR TIMESCALES OF MULTI-VENT BASALTIC ERUPTIONS IN BIG PINE VOLCANIC FIELD, CALIFORNIA.**
A. Zohar and E. Nagy-Shadman. California State University, Northridge, Department of Geological Sciences, Northridge, CA 91330.

50 P **CONSTRAINING THE RATE AND STYLE OF MAGMA ASCENT AT MAMMOTH MOUNTAIN, EASTERN CALIFORNIA.**
C. Wolfe and B. Browne. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92834.

51 P **BASALTIC VOLCANISM AND VOLCANIC HAZARDS AT BIG PINE VOLCANIC FIELD, INYO COUNTY, CALIFORNIA.**
Jeffrey M. Woolford and Jorge Vazquez. Department of Geological Sciences, California State University, Northridge, 18111 Nordhoff St., Northridge, CA 91330.

52 P **FIELD RELATIONSHIPS AND MINERAL ABUNDANCES OF THE ~5000 YEAR OLD BASALTS ERUPTED FROM RED CONES VOLCANOES, CALIFORNIA.**
A. Martos, M. Louros, and B. Browne. California State University Fullerton, Department of Geological Sciences, Fullerton, CA 92834.

53 P RHYOLITE MAGMATISM IN THE BIG PINE VOLCANIC FIELD, EASTERN CALIFORNIA.
M. I. Lidzbarski, J.A. Vazquez, and J.M. Woolford. Department of Geological Sciences, California State University, Northridge, CA 91330.

54 P CENOZOIC VOLCANISM ON THE DARWIN PLATEAU.
M.W. Lusk and D.R. Jessey. Geological Sciences Department, California State Polytechnic University, Pomona, CA 91768.

55 P PHYSICAL AND CHEMICAL CHARACTERISTICS OF VOLCANIC HOTSPRINGS AT WOTTEN WAVEN, DOMINICA, LESSER ANTILLES.
R. Herlihy, J.E. Fryxell, and A.L. Smith. California State University, San Bernardino, Department of Geological Sciences, San Bernardino, CA 92407.

56 P ERUPTIVE HISTORY OF SOUFRIERE VOLCANO, ST. VINCENT AS ILLUSTRATED BY THREE PYROCLASTIC SEQUENCES.
L.J. Estrella and A.L. Smith. Department of Geological Sciences, California State University, San Bernardino, CA 92407.

5:00–6:45 **Poster Session and Wine & Cheese Social**. *Courtyard.*

7:00–8:00 **Plenary Lecture**. *Portola Pavilions A & B.*
Dr. Francisco J. Ayala, Donald Bren Professor of Biological Sciences, University of California, Irvine.

DARWIN AND INTELLIGENT DESIGN

8:00–9:00 **Book-Signing Reception**. *Chapman Atrium.*

Friday, June 1, 2007
Location: GILMAN

Session: Contributed Papers

57 E 9:00 IMMIGRATION IN THE OCEAN: STATOLITHS AS LARVAL PASSPORTS.
S.E. Koch[1], G. Paradis[2], S.D. Gaines[2], R.R. Warner[2], and D.C. Zacherl[1]. [1]Department of Biological Science, California State University, Fullerton, P.O. Box 6850, Fullerton, CA 92834; [2]Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93101.

58 E 9:20 GLOBAL POPULATION STRUCTURE OF THE TOPE (*GALEORHINUS GALEUS*), AS INFERRED BY MITOCHONDRIAL CONTROL REGION SEQUENCE DATA.
C.L. Chabot. Nearshore Marine Fish Research Program, California State University, Northridge, Department of Biology, Northridge, CA 91330.

59 E 9:40 REPRODUCTIVE LONGEVITY IN THE POLYCHAETOUS ANNELID *DINOPHILUS GYROCILIATUS*.
Jessica Dewar and Cheryl Bube. Department of Biological Sciences, California State University, Long Beach, CA 90840.

60 E 10:00 THE MECHANISM OF MALE CHOICE IN THE SEMELPAROUS POLYCHAETE *NEANTHES ACUMINATA*.
Ellen J. Storey. Department of Biological Sciences, University of Hull, Cunningham Road, Hull, United Kingdom, HU6 7RX.

61 E 10:20 TO SETTLE OR NOT TO SETTLE: SEASONAL SETTLEMENT OF OYSTER LARVAE, *OSTREA CONCHAPHILA*, IN TWO SOUTHERN CALIFORNIA ESTUARIES.
E. M. Seale and D. C. Zacherl. Southern California Ecosystems Research Program, California State University, Fullerton, CA 92834.

10:40–11:00 BREAK

62 F 11:00 **MEDIAL RED MUSCLE DEVELOPMENT IN THE YELLOWFIN TUNA (*THUNNUS ALBACARES*).**
J. M. Dickson and K. A. Dickson. Department of Biological Science, California State University, Fullerton, CA 92831.

63 F 11:20 **AN EMBRYONIC STAGING SERIES FOR THE CALIFORNIA GRUNION, *LEURESTHES TENUIS*.**
C. L. Moravek, J. A. Flannery, and K. L. Martin. Pepperdine University, Department of Biology, Malibu, CA 90263.

64 F 11:40 **MICROSATELLITE AND MORPHOLOGICAL INVESTIGATION OF AN APPARENTLY DISJUNCT NORTHERN POPULATION OF CALIFORNIA GRUNION, *LEURESTHES TENUIS*.**
P.B. Johnson, T. Vandergon, R. Honeycutt, and K. Martin. Pepperdine University, Department of Biology, Malibu, CA 90263.

12:00–1:20 LUNCH BREAK

65 1:20 **RECIPE: A NOVEL RESEARCH PROJECT THAT IS MORE THAN HALF-BAKED.**
A. Dalkey. Palos Verdes Peninsula Land Conservancy, 916 Silver Spur Road #207, Rolling Hills Estates, CA 90274.

66 1:40 **EFFECTS OF A PURPOSE-BUILT UNDERPASS ON WILDLIFE ACTIVITY AND TRAFFIC-RELATED MORTALITY IN SOUTHERN CALIFORNIA: THE HARBOR BOULEVARD WILDLIFE UNDERPASS.**
David Elliott and Paul Stapp. Department of Biological Science, California State University, Fullerton, CA 92834.

67 E 2:00 **ETHNOBOTANY IN THE CANADIAN ARCTIC: A SURVEY OF THE COPPER INUIT.**
J. D. Davis and S. A. Banack. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92831.

68 E 2:20 **MALE CRICKET AGGRESSION AND PREDATION RISK: MALE CRICKETS FIGHTING OVER SPIDER SILK.**
L. J. Buena and S. E. Walker. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92831.

69 E 2:40 **A COMPARISON OF PREDATORY AND NON-PREDATORY MAMMAL MANAGEMENT POLICIES IN THE ELEVEN WESTERN STATES.**
J.B. Litvak. California State University, Fullerton, Department of Environmental Studies, Fullerton, CA 92834.

3:00–3:20 BREAK

70 E 3:20 **MOTH DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN SOUTHEAST ARIZONA.**
C. Francois and S. E. Walker. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92834.

71 3:40 **DIFFERENTIALLY ALTERING THE ABILITY OF *HAEMOPHILUS INFLUENZAE* TO FORM BIOFILMS BY USING SUBTHERAPEUTIC DOSES OF MULTIPLE ANTIBIOTICS.**
Yamila Hernandez, Ken Bradley, and Robert Damoiseaux. Palos Verdes Peninsula, 27118 Silver Spur Rd., Rolling Hills Estates, CA 90274; University of California, Los Angeles, Molecular Sciences Department, Los Angeles, CA 90095.

72 4:00 **IS YOUR BEACH IN HOT WATER? WARMING WATER TEMPERATURES CAUSE ERRONEOUS BACTERIAL EXCEEDANCES USING STANDARD BACTERIAL METHODS.**
L.A.A. Aumand, **A.L. Trinh**, and T.K. Smith-Kruck. Weston Solutions, Inc., Microbial Sciences Laboratories, 2433 Impala Dr., Carlsbad, CA 92010.

73 E 4:20 CONSEQUENCES OF MANY GENERATIONS OF HYBRIDIZATION UNDER BOTH STRESSFUL AND BENIGN CONDITIONS.
A. S. Hwang and S. Edmands. University of Southern California, Department of Biological Sciences, Los Angeles, CA 90089.

105 E 4:40 CONTROLS ON PLANT GAS EXCHANGE ACROSS A GRASSLAND TO SHRUBLAND GRADIENT IN OWENS VALLEY, CALIFORNIA.
C.M. Goedhart[1], D.E. Pataki[1], and S.A. Billings[2]. [1]University of California, Irvine, Department of Ecology and Evolutionary Biology, Irvine, CA 92697; [2]University of Kansas, Department of Ecology and Evolutionary Biology, Lawrence, KS 66045.

5:00–6:45 Poster Session and Wine & Cheese Social. *Courtyard.*

7:00–8:00 Plenary Lecture. *Portola Pavilions A & B.*
Dr. Francisco J. Ayala,
Donald Bren Professor of Biological Sciences, University of California, Irvine.

DARWIN AND INTELLIGENT DESIGN

8:00–9:00 Book-Signing Reception. *Chapman Atrium.*

Friday, June 1, 2007
Location: ALVARADO

Session: Biology of Rocky Reefs

Chair: Dan Pondella, Occidental College, and Robert Grove, Southern California Edison

74 11:00 PERSISTENCE AND ITS LIMITING FACTORS IN SOUTHERN CALIFORNIA KELP BEDS.
Michael D. Curtis. Senior Scientist, MBC Applied Environmental Sciences, Costa Mesa, CA.

75 11:20 A SATELLITE DERIVED DATABASE OF GLOBAL KELP CANOPY DISTRIBUTION.
Larry Deysher. PO Box 232296, Leucadia, CA 92023.

76 E 11:40 PHOTOACCLIMATION ALONG A VERTICAL GRADIENT IN DIFFERENT GROWTH STAGES IN THE ELK KELP, *PELAGOPHYCUS PORRA*.
Stacie M. Fejtek[1], Matthew S. Edwards[1], and Kwan-Young Kim[2]. [1]Department of Biology, San Diego State University, San Diego, CA; [2]Department of Oceanography, Chonnam National University, Gwangju, Korea.

12:00–1:20 LUNCH BREAK

77 1:40 COMMUNITY-BASED GIANT KELP RESTORATION AND MONITORING IN ORANGE COUNTY, CALIFORNIA.
N.L. Caruso. Kelp Project Manager, California Coastkeeper Alliance, PO Box 3156, Fremont, CA 94539.

78 2:00 RESTORED KELP BEDS OFF OF MALIBU AND PROGRESS OFF PALOS VERDES, WORTH DIVING FOR.
T. Ford. Santa Monica Baykeeper Kelp Restoration and Monitoring Project, P.O. Box 10096, Marina Del Rey, CA 90295.

79 E 2:20 **FISH-HABITAT ASSOCIATIONS AND THE ROLE OF DISTURBANCE IN SURFGRASS BEDS.**
Carey J. Galst. San Diego State University, Department of Biology, San Diego, CA 92182.

81 2:40 **EXTRAPOLATING RESULTS OF SMALL-SCALE FIELD EXPERIMENTS TO ENHANCE POPULATIONS OF A CORAL REEF FISH AT LARGE SPATIAL SCALES.**
Mark A. Steele and Graham E. Forrester. Department of Biology, California State University, Northridge, CA 91330; Department of Natural Resources Science, University of Rhode Island, Kingston, RI 02881.

3:00–3:20 **BREAK**

82 F 3:20 **THE RELATIVE EFFECTS OF BIOGEOGRAPHY AND SIZE-SELECTIVE FISHING PRESSURE ON THE POPULATION STRUCTURE AND SEX-CHANGE DYNAMICS OF THE CALIFORNIA SHEEPHEAD, *SEMICOSSYPHUS PULCHER*.**
L.S. Wetmore. Vantuna Research Group, Occidental College, Department of Biology, Los Angeles, CA 90041.

83 3:40 **ISOLATING THE EFFECTS OF LARVAL SOURCE ON THE POPULATION OF A MARINE INVERTEBRATE**
S.C. Schroeter[1], D. Reed[1], and P. Raimondi[2]. [1]Marine Science Institute, University of California, Santa Barbara, CA 93106; [2]Department of Ecology and Evolutionary Biology, University of California, Santa Cruz, CA.

84 4:00 **DEMOGRAPHIC PARAMETERS OF YELLOWFIN CROAKER, *UMBRINA RONCADOR* (PERCIFORMES: SCIAENIDAE) FROM THE SOUTHERN CALIFORNIA BIGHT.**
D. J. Pondella, II[1], J. T. Froeschke[2], L. S. Wetmore[1], E. Miller[3], C. F. Valle[4], and Lea Medeiros[1]. [1]Vantuna Research Group and Department of Biology, Moore Laboratory of Zoology, Occidental College, Los Angeles, CA 90041; [2]Texas A&M University - Corpus Christi, TX; [3]MBC Applied Environmental Sciences; [4]California Department of Fish and Game.

85 4:20 **FISH SPECIES COMPOSITION FROM THE SOFT-BOTTOM OF BAHÍA DE LOS ÁNGELES, BAJA CALIFORNIA, MEXICO (2005-2007).**
Jorge A. Rosales-Casian[1] and Phillip A. Hastings[2]. [1]Departamento de Ecología, Grupo de Ecología Pesquera, Centro de Investigación Científica y Educación Superior de Ensenada (CICESE), Km 107 carretera Tijuana-Ensenada, Ensenada, Baja California, México; [2]Scripps Institution of Oceanography, University of California San Diego, 9500 Gilman Dr., La Jolla, CA 92093.

86 4:40 **IMPACTS OF HABITAT USE ON CONTAMINANT CONCENTRATIONS IN SEVERAL SPECIES OF FISHES COLLECTED IN THE PALOS VERDES SUPERFUND SITE.**
D.A. Witting and G. Baker. NOAA Restoration Center, Long Beach, CA; NOAA Damage Assessment Center, Menlo Park, CA.

5:00–6:45 **Poster Session and Wine & Cheese Social**. *Courtyard.*

7:00–8:00 **Plenary Lecture**. *Portola Pavilions A & B.*
Dr. Francisco J. Ayala,
Donald Bren Professor of Biological Sciences, University of California, Irvine.

DARWIN AND INTELLIGENT DESIGN

8:00–9:00 **Book-Signing Reception**. *Chapman Atrium.*

Friday, June 1, 2007
Location: COURTYARD

Session: Poster Session, 5:00–6:45 p.m.

SEE PAPERS 47–56 FOR ADDITIONAL POSTERS

87 **BALLONA WETLANDS – BOLD VEGETATION GIS MAPPING PROJECT.**
Ned Bader and Pippa Drennan. Loyola Marymount University, College of Science and Engineering, Los Angeles, CA 90045.

88 M **THE EFFECT OF DL-HOMOCYSTEINE ON MINERALIZATION IN OSTEOBLAST-LIKE CELL CULTURES.**
M. Barakat, S. Choi, E.J. Jung, and E.E. Joseph. La Sierra University, Department of Biology, Riverside, CA 92505.

89 **NEUROTOXINS IN OUR ENVIRONMENT.**
T. Buretta and S. Banack. Institute for Ethnomedicine, California State University Fullerton, Department of Biological Science, Fullerton, CA 92831.

90 P **EVIDENCE FOR RAPID LAKE LEVEL CHANGE DURING THE LAST GLACIAL MAXIMUM IN SOUTHERN CALIFORNIA (LAKE ELSINORE).**
J.E. Carrasco, M.E. Kirby, and S.P. Lund. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92831.

91 M **BURST SWIMMING PERFORMANCE AND METABOLIC ENZYME ACTIVITIES IN LARVAL AND JUVENILE WHITE SEABASS (*ATRACTOSCION NOBILIS*).**
A. Carrillo and K. A. Dickson. Southern California Ecosystem Research Program, Department of Biological Science, California State University, Fullerton, CA 92834.

92 E **SONG RECOGNITION IN PLAYBACK EXPERIMENTS IN ANNA'S HUMMINGBIRD, *CALYPTE ANNA*.**
Carina Castro and Anne Houtman. Southern California Ecosystem Research Program, California State University, Fullerton, Department of Biological Science, Fullerton, CA 92831.

93 **BMAA, A NEUROTOXIN IN THE TRADITIONAL CHAMORRO FOOD.**
R. Cheng, M. Suazo, and S. Banack. Institute for Ethnomedicine, California State University Fullerton, Department of Biological Science, Fullerton, CA 92831.

94 M **CHARACTERIZING THE UPSTREAM REGULATORY REGION OF BP180.**
Jennifer Cherone and Amy Soto. Andersen Laboratory, University of California Irvine, Departments of Medicine (Endocrinology) and Biological Chemistry, Irvine, CA 92697.

95 E **AGGRESSION AND BIG HEADS: SEXUAL DIMORPHISM IN HOUSE CRICKETS (*ACHETA DOMESTICUS*).**
C. J. Collins, I. Adame, D. Lim, and S. E. Walker. Department of Biological Science, California State University, Fullerton, CA 92831.

96 **DOCUMENTATION OF COYOTES ON THE PALOS VERDES PENINSULA.**
Ann Dalkey[1] and Rebecca Niemiec[2]. [1]Palos Verdes Peninsula Land Conservancy, 916 Silver Spur Road #207, Rolling Hills Estates, CA 90274; [2]Chadwick High School, 26800 S. Academy Drive, Palos Verdes Peninsula, CA 90274.

97 E **HAS THE STATEWIDE BAN ON *CAULERPA* SPECIES BEEN EFFECTIVE? A SURVEY OF SOUTHERN CALIFORNIA AQUARIUM RETAIL STORES.**
S.H. Diaz[1], S.F. Zaleski[2], J.R. Smith[1], and S.N. Murray[1]. [1]Department of Biological Science, California State University, Fullerton, CA 92834; [2]Sea Grant Program, University of Southern California, Los Angeles, CA 90089.

98 E **ECOTONE BIODIVERSITY IN THE CHAPARRAL–RIPARIAN TRANSITION.**
S.C. Dobbie. Ecology and Paleoecology Research Group, Department of Life Sciences, Pasadena City College, CA 91106.

99 **ETHYLENE AS A POSSIBLE GERMINATION CUE FOR SAND VERBENAS (*ABRONIA* SPP., NYCTAGINACEAE).**
Philippa M. Drennan and Kristine Tulio. Loyola Marymount University, Department of Biology, Los Angeles, CA 90045.

100 **FIRES OF KELVIN CANYON.**
L.E. Eckert. California Polytechnic State University, Earth and Soil Sciences Department, San Luis Obispo, CA 93405.

101 E **INFLUENCE OF ANTHROPOGENIC NOISE ON SONG STRUCTURE IN ANNA'S AND COSTA'S HUMMINGBIRDS.**
Sarah English and Anne Houtman. Department of Biological Science, California State University, Fullerton, CA 92834.

102 E **THE EFFECTS OF HYDROPERIOD ON THE GROWTH RATES OF FLORIDA FLAGFISH, *JORDANELLA FLORIDAE*, IN THE FLORIDA EVERGLADES.**
S.M. Estes[1] and J.C. Trexler[2]. [1]University of California, Department of Ecology and Evolutionary Biology, Los Angeles, CA 90095; [2]Florida International University, Department of Biological Sciences, Miami, FL 33199.

103 **GEOCHRONOLOGY AND PALEOENVIRONMENT OF PLUVIAL HARPER LAKE, MOJAVE DESERT, CALIFORNIA.**
Anna L. Garcia and Jeffrey R. Knott. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92831.

104 F **POSSIBLE HEAT SOURCES FOR CRANIAL ENDOTHERMY IN THE YELLOWFIN TUNA.**
M. Garcia, I.M. Buan, R. Runcie, and K.A. Dickson. Department of Biological Science, California State University, Fullerton, CA 92834.

106 M **THE EFFECTS OF GLYPHOSATE ON PROLIFERATION OF *RANA PIPIENS* SPLENOCYTES STIMULATED WITH CON A AND PHA.**
Jeannie Gonzalez and Christine Broussard. Department of Biology, University of La Verne, La Verne, CA 91750.

107 **10-YEAR ASSESSMENT OF SOFT-BOTTOM MACROBENTHIC ASSEMBLAGES OFF THE COAST OF SAN DIEGO.**
R.N. Haring, T.D. Stebbins, D. Pasko, and D. James. City of San Diego Marine Biology Laboratory, Environmental Monitoring & Technical Services Division, Metropolitan Wastewater Department, San Diego, CA.

108 F **LENGTH, WEIGHT AND GENDER COMPARISONS OF THE BAY PIPEFISH (*SYNGNATHUS LEPTORHYNCHUS*) FROM THREE CENTRAL CALIFORNIA COASTAL LOCATIONS.**
M. Kodama, B. Lau, and J. M. Vallejo. University of California, Los Angeles, Department of Ecology and Evolutionary Biology, Los Angeles, CA 90095.

109 E **PREDATION IN EELGRASS BEDS: DO TROPHIC MANIPULATIONS RESULT IN CASCADING EFFECTS?.**
L.S. Lewis and T.W. Anderson. Fish Ecology Lab, San Diego State University, Department of Biology, San Diego, CA 92182.

110 **THE EFFECTS OF STRESS AND EXERCISE ON THE EXPRESSION OF BCL-2 ASSOCIATED PROTEIN X AND BRAIN-DERIVED NEUROTROPHIC FACTOR.**
H. T. Luu[1], D. E. Haack[2], M.J. Chen[2], and A. Russo-Neustadt[2]. [1]Alhambra High School, Alhambra, CA 91801; [2]Department of Biological Sciences, California State University, Los Angeles, CA 90032.

111 E **FEEDING RATES OF NATIVE CONSUMERS ON INTRODUCED AND NATIVE SEAWEEDS ON URBAN SOUTHERN CALIFORNIA SHORES.**
C.N. Navarro, J.R. Smith, and S.N. Murray. California State University Fullerton, Department of Biological Science, Fullerton, CA 92834.

112 E **PREDICTORS OF SUCCESSION IN A CHRONOSEQUENCE OF *IMPERATA* INFESTED COMMUNITIES.**
A.M. Nishimura. University of California, Los Angeles, Department of Ecology and Evolutionary Biology, Los Angeles, CA 90095.

113 M **THE EFFECTS OF SODIUM BUTYRATE ON THE ORGANIZATION OF ACTIN FILAMENTS IN U87MG BRAIN TUMOR CELLS.**
I. Oh, E. Liu, and J. Wilson. La Sierra University, Department of Biology, Riverside, CA 92515.

114 M **HYPOCHLORITE-INDUCED DEATH REVEALS THAT MICROPYLAR CELL DIVISION IS NOT NECESSARY FOR DEVELOPMENT OF *SPATHOGLOTTIS PLICATA* SEEDLINGS.**
R.S. Pardiwala and S. Darling Novak. University of La Verne, Department of Biology, La Verne, CA 91750.

115 E **THE EFFECTS OF AN INVASIVE PLANT SPECIES, *VINCA MAJOR*, ON ARTHROPOD COMMUNITIES IN RIPARIAN HABITAT AT STARR RANCH AUDUBON SANCTUARY, CALIFORNIA.**
E.S. Peralta and S.E. Walker. Southern California Ecosystems Research Program, California State University, Fullerton, Department of Biology, Fullerton, CA 92831.

116 M **THE POPULATION GENETICS OF ROUND STINGRAYS FROM SOUTHERN CALIFORNIA ASSESSED BY MICROSATELLITE MARKERS.**
S.M. Plank, C.G. Lowe, and J.A. Brusslan. California State University Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840.

117 E **FEEDING PREFERENCES OF THE MARINE GASTROPOD *APLYSIA VACCARIA*.**
M. R. Raith and D. C. Zacherl. Southern California Ecosystems Research Program, California State University, Fullerton, CA 92834.

118 M **INDUCED OXIDATIVE STRESS DECREASES MINERALIZATION IN BONE-LIKE CELL CULTURES.**
M. Rauf, A. Heyn, S. Torres, and E.E. Joseph. La Sierra University, Department of Biology, Riverside, CA 92505.

119 **COMPARISON OF THREE ANALYTICAL METHODS TO DETERMINE CHLOROPHYLL CONCENTRATION IN THE OCEAN.**
A.L. Register, L. Gilbane, and R. Pieper. Southern California Marine Institute, CICORE (Center for Integrative Coastal Observation Research & Education), San Pedro, CA 90731.

120 F **COMMUNITY STRUCTURE OF MACROPARASITES OF THE VERMILION ROCKFISH, *SEBASTES MINIATUS*, FROM RECREATIONAL FISHING CATCHES OF SAN QUINTÍN, BAJA CALIFORNIA, MEXICO.**
M.A. Rodriguez-Santiago[1] and J.A. Rosales-Casián[2]. [1]Facultad de Ciencias Marinas (UABC), Km 106 carretera Tijuana-Ensenada, Ensenada, Baja California, México, C.P. 22800; [2]Departamento de Ecología, Grupo de Ecología Pesquera, Centro de Investigación Científica y Educación Superior de Ensenada (CICESE), Km 107 carretera Tijuana-Ensenada, Ensenada, Baja California, México, C.P. 22800.

121 E **TEMPORAL AND SPATIAL VARIATION IN SETTLEMENT OF *OSTREA CONCHAPHILA* IN NEWPORT BAY, CALIFORNIA.**
Lily A. Sam and Danielle Zacherl. Southern California Ecosystems Research Program, Department of Biological Science, California State University, Fullerton, CA 92831.

122 M **THE EFFECTS OF SODIUM BUTYRATE ON U87MG BRAIN TUMOR CELL MIGRATION AND INVASION.**

C. Shaw, M. Sirichotiratana, A. Mesipam, and J. Wilson. La Sierra University, Department of Biology, Riverside, CA 92515.

123 E **ANTHROPOGENIC CONTROLS OF HARMFUL PHYTOPLANKTON TAXA IN SANTA MONICA BAY.**

A. Corcoran and R. Shipe. University of California Los Angeles, Department of Ecology and Evolutionary Biology & the Institute of the Environment, Los Angeles, CA 90095.

124 **EFFECT OF TEMPERATURE AND RATION LEVEL ON THE GROWTH OF YOUNG-OF-THE YEAR COHO SALMON (*ONCORHYNCHUS KISUTCH*): A COMPARISON BETWEEN OREGON AND CENTRAL CALIFORNIA STOCKS.**

Erick A. Sturm, John M. Silveus, and R. Bruce MacFarlane. National Marine Fisheries Service, 110 Shaffer Road, Santa Cruz, CA 95060.

125 **PERCENT METHYLATION AND ITS RELATIONSHIP WITH AGING.**

Shelly Tat and Dr. Shibata. USC Norris Cancer Center, 1441 Eastlake Ave., Los Angeles, CA 90033.

126 P **DETERMINING THE TIMING AND OFFSET OF SECONDARY NORMAL FAULTS IN THE KIT FOX HILLS ADJACENT THE NORTHERN DEATH VALLEY FAULT ZONE.**

B.M. Taylor and J.R. Knott. California State University Fullerton, Department of Geological Sciences, Fullerton, CA 92831.

127 F **DEVELOPMENT OF JAW MUSCULO-SKELETAL STRUCTURE IN THE YELLOW-FIN TUNA AND THE EASTERN PACIFIC BONITO.**

S. Truong and K.A. Dickson. Department of Biological Science, California State University, Fullerton, CA 92831.

128 E **MORPHOLOGICAL VARIATION OF *YUCCA BREVIFOLIA* (AGAVACEAE) AMONG SEVEN POPULATIONS IN THE MOJAVE DESERT.**

T. R. Valentovich and D. R. Sandquist. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92831.

129 M **THE ACETYLCHOLINESTERASE INHIBITOR MALATHION IS NOT TOXIC TO THYMOCYTES, BUT MAY ALTER THE DEVELOPMENTAL PROGRAM AT LOW DOSES.**

Christine Broussard and **Jessica Varney**. Department of Biology, University of La Verne, La Verne, CA 91750.

130 M **EFFECTS OF METHOXYCHLOR EXPOSURE ON THE DEVELOPMENT OF CD4 T-CELLS IN C57BL/6 MICE.**

A.J. Vasa and Christine Broussard. Department of Biology, University of La Verne, La Verne, CA 91750.

131 **COMPUTATIONAL ANALYSIS OF GRAINYHEAD-LIKE EPITHELIAL TRANSACTIVATOR (GET1) REGULATED GENES.**

Madhvi Venkatesh, Ambica Bhandari, and Bogi Andersen. University of California, Department of Biological Chemistry, Irvine, CA 92697.

132 M **THE EFFECTS OF SODIUM BUTYRATE ON THE SECRETION OF MATRIX METALLOPROTEINASES BY U87MG BRAIN TUMORS.**

B. Villegas, M. Kim, J. Hoang, and J. Wilson. La Sierra University, Department of Biology, Riverside, CA 92515.

133 E **EXPERIMENTAL RESTORATION OF THE ROCKY INTERTIDAL BROWN ALGA *SILVETIA COMPRESSA* ON URBAN SOUTHERN CALIFORNIA SHORES.**
Stephen G. Whitaker, J.R. Smith, and S.N. Murray. California State University Fullerton, Department of Biological Science, Fullerton, CA 92834.

134 E **SPATIAL AND TEMPORAL VARIATION IN δ^{13}C AND δ^{15}N VALUES OF MACROALGAE IN SOUTHERN CALIFORNIA WATERS.**
S.C. Vogt.[1], L. Gilbane[2], A. Bullard[1], J.R. Smith[1], and S.N. Murray[1]. [1]Department of Biological Science, California State University, Fullerton, CA 92834; [2]Southern California Marine Institute, Terminal Island, CA 90731.

135 **HEAT SHOCK PROTEIN 70 (HSP70) EXPRESSION IN MULTIPLE SCLEROSIS.**
Amy Young. Multiple Sclerosis Research Group, University of Southern California, Keck School of Medicine, McKibben Hall, 1333 San Pablo Street, Los Angeles, CA 90033.

136 **A STUDY OF FECAL INDICATOR BACTERIA IN THE BALLONA WETLANDS AND DEL REY LAGOON, LOS ANGELES, CALIFORNIA.**
S. Yanamadala and J.H. Dorsey. Chadwick School, 26800 S. Academy Drive, Palos Verdes, CA 90274.

137 **GEOGRAPHICAL, TAXONOMICAL, TEMPORAL AND HOST SIZE/AGE COMPARISONS OF INTESTINAL PARASITES IN THREE SPECIES OF SCULPINS.**
Jonathan Sim, Kathryn Fabella, and Alexander Mack Cruz. University of California, Los Angeles, CA 90095.

Saturday, June 2, 2007
Location: GABRIELINO

Session: Paleontology of Southern California

Chair: Mark Roeder, San Diego Museum of Natural History

138 E 9:00 **A TAXONOMIC REVIEW OF LATE CRETACEOUS CIMOLESTIDS.**
J.J. Strauss. San Diego State University, Department of Biology, San Diego, CA 92182.

139 9:20 **PRELIMINARY REVISION OF AGRIOCHOERID OREODONTS OF SOUTHERN CALIFORNIA.**
J. A. Ludtke. San Diego State University, Department of Biology, San Diego, CA 92182.

140 E 9:40 **PHYLOGENETIC POSITION AND BIOGEOGRAPHICAL IMPLICATIONS OF SOUTHERN CALIFORNIA TORTOISES.**
C.B. Jones. San Diego State University, Department of Biology, San Diego, CA 92182.

141 10:00 **LAND MAMMALS FROM THE MIDDLE MIOCENE SHARKTOOTH HILL BONEBED, KERN COUNTY, CALIFORNIA.**
Donald R. Prothero[1], Matthew R. Liter[1], Lawrence G. Barnes[2], and Xiaoming Wang[2]. [1]Department of Geology, Occidental College, Los Angeles, CA 90041; [2]Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007.

142 10:20 **A NORTHERN OCCURRENCE OF THE COTTON RAT *SIGMODON MEDIUS* WITH *PLIOPHENACOMYS PRIMAEVUS* FROM LATE PLIOCENE AGE DEPOSITS OF MODOC COUNTY, NORTHEASTERN CALIFORNIA.**
Hugh M. Wagner. Department of Paleontology, San Diego Natural History Museum, P.O. Box 121390, San Diego, CA.

10:40–11:00 **BREAK**

11:00–11:20 **Student Grant Awards**. *Titan Theatre.*

11:20–12:20 **Plenary Lecture**. *Titan Theatre.*
Dr. Steve Murray, Dean of Natural Sciences and Mathematics, California State University, Fullerton.

SCIENCE, POLITICS, THE PUBLIC AND PROTECTING CALIFORNIA'S COASTAL MARINE ECOSYSTEMS

12:20–1:20 **LUNCH BREAK**

143 **1:20** **A NEW IRVINGTONIAN LAND MAMMAL ASSEMBLAGE FROM THE SAUGUS FORMATION, MOORPARK, VENTURA COUNTY, CALIFORNIA.**
Hugh M. Wagner[1], E. Bruce Lander[1], Mark A. Roeder[1], Donald R. Prothero[2], and George E. McDaniel, Jr.[3] [1]Paleo Environmental Associates, Inc., 2248 Winrock Ave., Altadena, CA 91001; [2]Occidental College, Department of Geology, 1600 Campus Rd., Los Angeles, CA 90041; [3]Anza-Borrego Desert State Park, Stout Paleontology Laboratory, P.O. Box 1720, Borrego Springs, CA 92004.

144 **1:40** **REVISED TEMPORAL RESOLUTION OF THE LATE IRVINGTONIAN AGE FAIRMEAD LANDFILL FAUNA, MADERA COUNTY, CALIFORNIA.**
Hugh M. Wagner[1] and L.H. Fisk[2]. [1]Department of Paleontology, San Diego Natural History Museum, P.O. Box 121390, San Diego, CA; [2]PaleoResource Consultants, 5325 Elkhorn Boulevard, #294, Sacramento, CA 95842.

145 **2:00** **NEW RECORDS OF FOSSIL SHARKS AND BONY FISHES FROM THE LATE MIOCENE IMPERIAL GROUP OF THE ANZA BORREGO REGION, SAN DIEGO COUNTY, CALIFORNIA.**
Mark A. Roeder[1] and Jerry M. Hughes[2]. [1]Department of Paleontology, San Diego Natural History Museum, P. O. Box 121390, San Diego, CA 92112; [2]Colorado District Stout Research Center, Anza Borrego Desert State Park, 200 Palm Canyon Drive, Borrego Springs, CA 92004.

146 **2:20** **A FOSSIL ZIPHIID WHALE (CETACEA: ODONTOCETI) FROM THE LATEST MIOCENE CAPISTRANO FORMATION IN SOUTHERN ORANGE COUNTY, CALIFORNIA.**
Mark R. Deering[1], Lawrence A. Barnes[2], Sarah A. Siren[1,3], Samuel A. McLeod[2], Maureen O. Walsh[1], and Karin A. Rice[1]. [1]Stantec Consulting Inc., 19 Technology Drive, Irvine, CA 92618; [2]Department of Vertebrate Paleontology, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007; [3]Saddleback College, 28000 Marguerite Parkway, Mission Viejo, CA 92692.

147 **2:40** **A MAMMOTH AND ASSOCIATED FAUNA FROM NEWPORT BACKBAY 25,000 YEARS BEFORE PRESENT.**
S. Gust and K. Scott. Cogstone Resource Management Inc., 1801 E. Parkcourt Place, Ste. B102, Santa Ana, CA 92701.

3:00–3:20 **BREAK**

148 E **3:20** **VARIATION AND SEXUAL SIZE DIMORPHISM IN PLEISTOCENE GROUND SLOTHS (XENARTHRA).**
Kristina R. Raymond and Donald R. Prothero. Department of Geology, Occidental College, Los Angeles, CA 90041.

149 **3:40** **PALEOENVIRONMENTAL INTERPRETATIONS OF PLEISTOCENE DEPOSITS AT THE PACIFIC CITY PROJECT SITE IN HUNTINGTON BEACH, SOUTHERN CALIFORNIA.**
L.H. Fisk[1] and M.R. Roeder[2]. [1]PaleoResource Consultants, 5325 Elkhorn Boulevard, #294, Sacramento, CA 95842; [2]Paleo Environmental Associates, Inc., 1731 New Hampshire Drive, Costa Mesa, CA 92626.

Saturday, June 2, 2007
Location: ONTIVEROS

Session: Avian Biology

Chair: Kathy Keane, Keane Biological Consulting

Saturday, June 2, 2007

150 E 9:00 **NESTING SUCCESS OF COSTA'S HUMMINGBIRD IN ARTICHOKE THISTLE INVADED CALIFORNIA GRASSLANDS.**
R.J. Keber and S.A. Banack. Southern California Ecosystems Research Program, California State University, Fullerton, Department of Biological Science, Fullerton, CA 92834.

151 9:20 **POPULATION STATUS AND TRENDS OF THE CALIFORNIA LEAST TERN, *STERNULA ANTILLARUM BROWNI*, AND THE WESTERN SNOWY PLOVER, *CHARADRIUS ALEXANDRINUS NIVOSUS*.**
Jack M. Fancher. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, CA 92011.

152 E 9:40 **DISTRIBUTION AND HABITAT ANALYSIS OF THE WESTERN BURROWING OWL IN AN URBANIZING ENVIRONMENT.**
Ginny A. Short. University of California, Riverside, Department of Biology, Riverside, CA 92521.

153 10:00 **2006 CACTUS WREN STUDY, NATURE RESERVE OF ORANGE COUNTY.**
R.A. Hamilton and M.J. Mitrovich. Nature Reserve of Orange County, 15600 Sand Canyon Avenue, Irvine, CA 92618.

154 10:20 ***CHARADRIUS ALEXANDRINUS* POPULATION SURVEYS AT OWENS DRY LAKE, INYO COUNTY CALIFORNIA PRE- AND POST SHALLOW FLOOD DUST CONTROL IMPLEMENTATION.**
G.M. Honan[1], R. Romero[1], J. Gorham[1], G.W. Page[2], and T.D. Ruhlen[2]. [1]CH2M HILL, Santa Ana, CA; [2]PRBO Conservation Science, Petaluma, CA.

10:40–11:00 **BREAK**

11:00–11:20 **Student Grant Awards**. *Titan Theatre.*

11:20–12:20 **Plenary Lecture**. *Titan Theatre.*
Dr. Steve Murray, Dean of Natural Sciences and Mathematics, California State University, Fullerton.

SCIENCE, POLITICS, THE PUBLIC AND PROTECTING CALIFORNIA'S COASTAL MARINE ECOSYSTEMS

12:20–1:20 **LUNCH BREAK**

Location: ONTIVEROS

Session: Hydrology and Aquatic Life of the Santa Ana River

Chair: Richard Zembal, Orange County Water District

155 1:20 **THE SANTA ANA RIVER FROM CREST TO CREST – A PHOTO EXPLORATION.**
Patrick Michell.

156 1:40 **LEAST BELL'S VIREOS OF THE SANTA ANA RIVER – RECOVERY IN PROGRESS.**
S. Hoffman, R. Zembal, J. Pike, D. Pelligrini, T. Wiater, B. Nash, M. Aimar, T. Reeser, A. Beckman, and J. Coumoutso. The Santa Ana Watershed Association, 25864-K Business Center Dr., Redlands, CA 92374.

157 2:00 **RESTORATION OF THE RIPARIAN FORESTS OF THE SANTA ANA RIVER. THE SANTA ANA RIVER WATERSHED PROGRAM, 1997–2007.**
Richard Zembal. Natural Resources Director, Orange County Water District, 10500 Ellis Avenue, Fountain Valley, CA 92708.

158 2:20 **HERPETOLOGICAL SURVEYS OF THE SANTA ANA WATERSHED.**
M. Aimar, R. Zembal, J. Bradley, S. Hoffman, B. Nash, T. Wiater, T. Reeser, A. Beckman, and J. Coumoutso. Santa Ana Watershed Association, 25864-K Business Center Dr., Redlands, CA 92374.

159 2:40 **HISTORICAL CHANGES IN THE FRESHWATER FISH FAUNA OF THE SANTA ANA RIVER.**
Camm C. Swift[1] and **Roy Leidy**[2]. [1]Entrix, Inc., 2140 Eastman Avenue, Suite 200, Ventura, CA 93003; [2]EIP Associates, a division of PBS&J, 1200 Second Street, Suite 200, Sacramento, CA 95814.

3:00–3:20 **BREAK**

160 3:20 **BIOLOGIC, HISTORIC AND SOCIAL CONSIDERATIONS FOR INTRODUCTIONS OF SANTA ANA SUCKER (*CATOSTOMUS SANTAANAE*) AND SANTA ANA SPECKLED DACE (*RHINICHTHYS OSCULUS* SSP.) INTO THE UPPER SANTA ANA RIVER.**
Gar Abbas. USDA Forest Service, San Bernardino National Forest, San Bernardino, CA 92408.

161 3:40 **FLORA OF THE SANTA ANA RIVER.**
Oscar F. Clarke and Greg Ballmer.

162 4:00 **DEMYSTIFYING A RARE AND SECRETIVE SPECIES OF THE SANTA ANA RIVER, THE SOUTH COAST GARTERSNAKE (*THAMNOPHIS SIRTALIS* SSP.).**
Edward L. Ervin[1], Clark R. Mahrdt[2], and Bonnie Nash[3]. [1]Merkel & Associates, Inc., San Diego, CA 92123; [2]San Diego Natural History Museum, San Diego, CA 92101; [3]Orange County Water District, Fountain Valley, CA 92708.

163 4:20 **CHANGES IN HABITAT AFFECT THE POPULATION DYNAMICS OF THE FEDERALLY THREATENED SANTA ANA SUCKER, *CATOSTOMUS SANTAANAE*, IN THE SANTA ANA RIVER.**
Andrew Thompson[1], Jonathan Baskin[2, 3], and Tom Haglund[2, 3]. [1]U.S. Fish and Wildlife Service, 6010 Hidden Valley Road, Carlsbad, CA 92011; [2]Biological Sciences Department, California State Polytechnic University Pomona, 3801 West Temple Avenue, Pomona, CA 91768; [3]San Marino Environmental Associates, 560 South Greenwood Ave., San Marino, CA 91108.

164 4:40 **AQUATIC INSECTS OF THE SANTA ANA RIVER: COMMUNITY STRUCTURE AND BIOASSESSMENT ON ALTITUDINAL GRADIENT.**
W. E. Walton and B. A. Mullens. Department of Entomology, University of California, Riverside, CA 92521.

Saturday, June 2, 2007
Location: ALVARADO

Session: Diseases and other Maladies of Southern California Marine Mammals

Chair: Richard H. Evans, Pacific Marine Mammal Center

165 E 8:20 ***PSEUDO-NITZSCHIA* BLOOM DYNAMICS IN COASTAL WATERS NEAR LOS ANGELES AND CONFIRMED CASES OF DOMOIC ACID POISONING IN MARINE MAMMALS.**
A. Schnetzer[1], D.A. Caron[1], L. Palmer[2], M. Hunter[3], and R. Evans[3]. [1]Department of Biological Sciences, University of Southern California, Los Angeles, CA 90089; [2]Marine Mammal Care Center at Fort McArthur, San Pedro, CA 90732; [3]Pacific Marine Mammal Center, Laguna Beach, CA 92651.

166 8:40 **DOMOIC ACID POISONING OF CALIFORNIA SEA LIONS IN SOUTHERN CALIFORNIA WATERS: CLINICAL AND PATHOLOGICAL FINDINGS.**
R. H. Evans. Pacific Marine Mammal Center, 20612 Laguna Canyon Road, Laguna Beach, CA 92651.

167 9:00 **LEVELS OF PCBS AND DDT IN PINNIPEDS OF THE SOUTHERN CALIFORNIA BIGHT.**
Mary Blasius and G.D. Goodmanlowe. California State University, Long Beach, CA 90840.

168 9:20 **A PRELIMINARY EXAMINATION OF MORTALITY PATTERNS IN STRANDED SAN DIEGO COUNTY CETACEANS, 1978–2006.**
K. Danil[1] and J. St. Leger[2]. [1]Southwest Fisheries Science Center, 8604 La Jolla Shores Dr., La Jolla, CA 92037; [2]Sea World, 500 Sea World Dr., San Diego, CA 92109.

169 9:40 ***STAPHYLOCOCCUS AUREUS* NEPHRITIS IN A CALIFORNIA SEA LION (*ZALOPHUS CANUS*)**
V. Favel. Pacific Marine Mammal Center, 20612 Laguna Canyon Road, Laguna Beach, CA 92651.

170 10:00 **BRUCELLA IN MARINE MAMMALS.**
Judy St. Ledger. SeaWorld, 500 Sea World Dr., San Diego, CA 92109.

171 10:20 **MISCELLANEOUS CASE REPORTS AND "SWEET TREATMENT" OF A SHARK BITE.**
Lauren Palmer. Marine Mammal Care Center, Fort MacArthur, San Pedro, CA.

10:40–11:00 **BREAK**

11:00–11:20 **Student Grant Awards**. *Titan Theatre.*

11:20–12:20 **Plenary Lecture**. *Titan Theatre.* **Dr. Steve Murray**, Dean of Natural Sciences and Mathematics, California State University, Fullerton.

SCIENCE, POLITICS, THE PUBLIC AND PROTECTING CALIFORNIA'S COASTAL MARINE ECOSYSTEMS

12:20–1:20 **LUNCH BREAK**

Saturday, June 2, 2007
Location: GILMAN

Session: Contributed Papers

172 9:00 **TIDAL DYNAMICS OF FECAL INDICATOR BACTERIA (FIB) IN THE BALLONA WETLANDS, LOS ANGELES COUNTY, CALIFORNIA.**
A. A. Antonino[1], P. M. Carter[1], M. R. Ogletree[1], J. H. Dorsey[1] and R. Sagarin[2]. [1]Loyola Marymount University, Department of Natural Science, Los Angeles, CA 90045; [2]Nicholas Institute for Environmental Policy Solutions, Box 90328, Duke University, Durham, NC 27708.

173 E 9:20 **PRELIMINARY ETHNOBOTANICAL INVESTIGATION ON CURRENT USE OF *HYDROCOTYLE RANUNCULOIDES L.F.* IN IXTLAHUCA AND SAN MATEO, TEXCALYACAC, MEXICO.**
C.J. Cortez and S.A. Banack. Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92834.

174 M 9:40 **THE USE OF BEDSIDE ULTRASOUND TO DETECT FREE FLUID IN TRAUMA PATIENTS.**
Jarrod L. Larson, J. Christian Fox, Graciela Barajas, and Suleman Ahmed. University of California, Irvine Medical Center, University of California, Irvine, Department of Emergency Medicine, Orange, CA 92868.

175 10:00 **ARMORED MIXED-SOFT SEDIMENTS - A DISTINCTIVELY DIFFERENT SEDIMENT PARADIGM?.**
D. C. Lees[1] and W. B. Driskell[2]. [1]Littoral Ecological & Environmental Services, 1075 Urania Ave., Leucadia, CA 92024; [2]6536 20th Ave. NE, Seattle, WA 98115.

176 10:20 **DELAYED RECOVERY IN INTERTIDAL CLAM ASSEMBLAGES IN PRINCE WILLIAM SOUND FOLLOWING THE *EXXON VALDEZ* OIL SPILL CLEANUP.**
D. C. Lees[1] and W. B. Driskell[2]. [1]Littoral Ecological & Environmental Services, 1075 Urania Ave., Leucadia, CA 92024; [2]6536 20th Ave. NE, Seattle, WA 98115.

10:40–11:00 **BREAK**

11:00–11:20 **Student Grant Awards**. *Titan Theatre.*

11:20–12:20 **Plenary Lecture**. *Titan Theatre.*
Dr. Steve Murray, Dean of Natural Sciences and Mathematics, California State University, Fullerton.

SCIENCE, POLITICS, THE PUBLIC AND PROTECTING CALIFORNIA'S COASTAL MARINE ECOSYSTEMS

12:20–1:20 **LUNCH BREAK**

Saturday, June 2, 2007
Location: ALVARADO

Session: Contributed Papers

177 1:20 **BALANCING RANIDS AND RECREATION: FOREST SERVICE EFFORTS TO PROTECT MOUNTAIN YELLOW-LEGGED FROGS AND QUALITY RECREATION OPPORTUNITIES.**
Gar Abbas, Anne Poopatanapong, and Marc Stamer. USDA Forest Service, San Bernardino National Forest, San Bernardino, CA 92408.

178 M 1:40 **CHRONOTROPIC AND INOTROPIC EFFECTS OF HAWTHORN (*CRATAEGUS OXYCANTHA*) EXTRACTS IN CARDIOMYOCYTE-BASE ASSAY.**
Satin Salehi, Shannon R. Long, Kristi M. Crofoot, and Theresa M. Filtz. Oregon State University, College of Pharmacy, Corvallis, OR.

179 F 2:00 **EFFECTS OF INCREASED CURRENT VELOCITY ON THE GROWTH OF JUVENILE CAPTIVE BROODSTOCK COHO SALMON (*ONCORHYNCHUS KISUTCH*).**
John Silveus and Erick Sturm. Southwest Fisheries Science Center, National Marine Fisheries Service, 110 Shaffer Road, CA 95060.

180 2:20 **ADDITIONAL RECORDS FOR PACIFIC HADAL ZONE ECHINODERMS.**
K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037.

181 2:40 **WHALE FALL DEPLETION AND ECOSYSTEM EFFECTS FOR ABYSSAL/HADAL MEGAFAUNA ECHINODERMS.**
K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037.

3:00–3:20 **BREAK**

182 3:20 **DYNAMICS OF PLANETARY INTERIOR OCEANS AND SURFACE EXPANSION OF POTENTIAL ECOSYSTEMS.**
K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037.

183 F 3:40 **SEASONAL AGGREGATIONS OF FEMALE ROUND STINGRAYS (*UROBATIS HALLERI*) IN A COASTAL ESTUARY.**
C.G. Mull, K.A. Young, and C.G. Lowe. Department of Biological Sciences, California State University, Long Beach, CA 90840.

Saturday, June 2, 2007
Location: HETEBRINK

Session: Research Training Program

Chair: Dr. Martha Schwartz, Southern California Junior Academy of Sciences Committee

184 9:00 **CIRCUIT DYNAMICS AND MODELING OF THE GAUSS ACCELERATOR.**
J. Luo and O. O. Bernal. California State University Los Angeles, Department of Physics and Astronomy, Los Angeles, CA 90032.

185 9:20 **A STUDY OF ENTEROBACTERIACEAE AT TWO ENCLOSED BEACHES IN LOS ANGELES, CALIFORNIA.**
S. Yanamadala and J.H. Dorsey. Chadwick School, 26800 S. Academy Drive, Palos Verdes, CA 90274.

186 9:40 **EXPLORATION OF PROTEIN LRP16'S FUNCTION AS A RESULT OF ITS CORRESPONDING DNA SEQUENCES THROUGHOUT THE EVOLUTIONARY TREE.**
Shahla Naimi. California Academy of Math and Science, Carson, CA 90747.

187 10:00 **PERMANENT UPLIFT OF THE MENTAWAI ISLANDS AND THE MEGATRUST EARTHQAUKE CYCLE.**
Hassan Ahmad. 501 N Chapel Ave. #1, Alhambra, CA 91801.

188 10:20 **PHYSICAL ASPECTS OF SOUTHERN CALIFORNIA BEACHES AND HOW PEOPLE PERCEIVE THEM: CONSIDERATIONS FOR BEACH NOURISHMENT PLANNING.**
Scott H. Grove. Sonora High School, La Habra, CA; California State University, Monterey Bay, CA.

10:40–11:00 **BREAK**

11:00–11:20 **Student Grant Awards**. *Titan Theatre.*

11:20–12:20 **Plenary Lecture**. *Titan Theatre.* **Plenary Lecture**. *Titan Theatre.*
Dr. Steve Murray, Dean of Natural Sciences and Mathematics, California State University, Fullerton.

SCIENCE, POLITICS, THE PUBLIC AND PROTECTING CALIFORNIA'S COASTAL MARINE ECOSYSTEMS

12:20–1:20 **LUNCH BREAK**

189 1:20 **PRODUCTION AND CHARACTERIZATION OF EFFICIENT C60-TETHERED AU NANOPARTICLES FOR THE DELIVERY OF PHOTOSENSITIZERS.**
May Y. Chow[1] and Matthias Selke[2]. [1]Alhambra High School, Alhambra, CA 91801; [2]California State University, Los Angeles, CA.

190 1:40 **THE SIGNAL TRANSDUCTION PATHWAY FOR MUSCLE CELL APOPTOSIS IN AGING AND INJURY.**
Sanjit Datta and A.P. Sinha Hikim. Los Angeles Biomedical Research Institute at the Harbor-UCLA Medical Center, Harbor City, CA 90710.

191 2:00 **A CASE-CONTROL STUDY OF COMMUNITY-ACQUIRED METHICILLIN RESISTANT *STAPHYLOCCUS AUREUS* SKIN AND SOFT TISSUE INFECTIONS AMONG INMATES IN THE LOS ANGELES COUNTY JAIL.**
Ji-Mi (Jenny) Lee. California Academy of Mathematics and Science (CAMS), Carson, CA 90747; California State University, Dominguez Hills, 100 East Victoria Street, Carson, CA 90747.

192 2:20 **THE ABILITY OF *BACCHARIS SALICIFOLIA* TO ABSORB CADMIUM AS AN EFFLUENT: IMPLICATIONS FOR PHYTOREMEDIATION: YEAR TWO.**
Nisha Wadhwa[1] and Katie Brandt[2]. [1]Palos Verdes Peninsula High School, Rolling Hills Estates, CA; [2]California State University, Dominguez Hills, CA.

193 2:40 **PROTEASE INHIBITORS IN AUGMENT TEMOZOLOMIDE-BASED TREATMENT FOR MALIGANT GLIOMAS**
J.J. Wang, W.J. Wang, and T.C. Chen. Department of Neurosurgery, University of Southern California, Los Angeles, CA 90033.

3:00–3:20 **BREAK**

194 3:20 **OXIDATION OF L-DOPA IN MUSSEL BYSSUS DISC ADHESION.**
Renee Bogdanovic. Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274.

195 3:40 **STUDY ON THE TRUNCATION OF CONVEX SYMMETRICAL POLYHEDRA.**
Brian Li. Chadwick School, 26800 S. Academy Drive, Palos Verdes, CA.

196 4:00 **PREDICTING LUNG CANCER RELAPSE USING LEVELS OF 2881 PROTEINS.**
Timothy Wu[1] and Dennis Kibler[2]. [1]University High School, 4771 Campus Drive, Irvine, CA 92612; [2]University of California, Irvine, CA 92697.

197 4:20 **PROTOCOLS FOR *HALIOTIS RUFESCENS* EGG CRYOPRESERVATION AND *IN VITRO* FERTILIZATION (YEAR 2).**
Julie A. Guerin. Cabrillo Marine Aquarium, San Pedro, CA 90731; Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274.

198 4:40 **MAGNETORHEOLOGICAL FLUID SHEER STRESS AND THE MORPHING OF AIRPLANE WINGS.**
Anshu Vaish. Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274.

STUDENT AWARD WINNERS AT THE 2007 ANNUAL MEETING

At the 2007 Annual Meeting, the following student papers and posters won awards.

Best Posters:

Best Poster, Ecology and Evolution

A. Corcoran and R. Shipe (Dept. of Ecology and Evolutionary Biology and Dept. of Health Sciences, UCLA)
ANTHROPOGENIC CONTROLS OF HARMFUL PHYTOPLANKTON TAXA IN SANTA MONICA BAY

Honorable Mention:

L. S. Lewis and T. W. Anderson (Fish Ecology Lab, San Diego State University)
PREDATION IN EELGRASS BEDS: DO TROPHIC MANIPULATIONS RESULT IN CASCADING EFFECTS?

Best Poster, Molecular Biology and Physiology:

A. J. Vasa and Christine Broussard (Dept. of Biology, University of La Verne)
EFFECTS OF METHOXYCHLOR EXPOSURE ON THE DEVELOPMENT OF CD4 T-CELLS IN C57BL/6 MICE""

Honorable Mention;

A. Carrillo and K. A. Dickson (Dept. of Biological Science, CSU-Fullerton)
BURST SWIMMING PERFORMANCE AND METABOLIC ENZYME ACTIVITIES IN LARVAL AND JUVENILE WHITE SEABASS (*ATRACTOSCION NOBILIS*)

Best Poster, Physical Science (Tie)

C. Wolfe and B. Browne (Dept. of Geological Sciences, CSU-Fullerton)
CONSTRAINING THE RATE AND STYLE OF MAGMA ASCENT AT MAMMOTH MOUNTAIN, EASTERN CALIFORNIA

M. W. Lusk and D. R. Jessey (Geological Sciences Department, California State Polytechnic University, Pomona)
CENOZOIC VOLCANISM ON THE DARWIN PLATEAU

Best Papers,

Ecology and Evolution: (TIE)

C. L. Chabot, Dept. of Biology, California State University, Northridge
GLOBAL POPULATION STRUCTURE OF THE TOPE (*GALEORHINUS GALEUS*), AS INFERRED BY MITOCHONDRIAL CONTROL REGION SEQUENCE DATA

E. M. Seale and D. C. Zacherl Southern California Ecosystems Research Program, California State University, Fullerton

TO SETTLE OR NOT TO SETTLE: SEASONAL SETTLEMNT OF OYSTER LARVAE, *OSTREA CONCHAPHILA*, IN TWO SOUTHERN CALIFORNIA ESTUARIES

Molecular Biology and Physiology:

Heather Johnston, E. Guirges, and E. N. Kageno, Dept. of Ecology and Evolutionary Biology, UCLA

THE EFFECTS OF THE ECTOPARASITIC ISOPOD *ELTHUSA CALIFORNICA* ON THE RESPIRATION OF THE SURF PERCH *CYMATOGASTER AGGREGATA*

Physical Sciences:

Michael Blazevic, M. Kirby, A. Woods, B. Browne, and D. Bowman, Dept. of Geological Sciences, California State University, Fullerton

HIGH-RESOLUTION THIN-SECTION PHOTOMICROGRAPHY ANALYSIS OF A GLACIAL-AGE SEDIMENT CORE FROM BALDWIN LAKE, SOUTHERN CALIFORNIA: A LOOK AT SOME INITIAL RESULTS

Southern California Academy of Sciences 2007 Annual Meeting Abstracts

1. TROUBLED WATERS: THE BIOLOGICAL INVASION OF SOUTHERN CALIFORNIA WATERWAYS

Louanne McMartin. Non-native Invasive Species Program, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Stockton, CA 95205

Throughout North America the spread of non-native species threatens the ecological integrity of forests, grasslands, and waterways and causes significant economic stress in our communities. Identification of aquatic nuisance species is key in addressing the threat to southern California aquatic ecosystems and water delivery systems. This presentation will profile some of the aquatic nuisance species in southern California providing biological characteristics, life history, environmental requirements and the potential ecological impacts they pose.

2. THE INVASIVE *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) IN CALIFORNIA WITH DATA FROM THE UPPER OWENS RIVER WATERSHED

G.K. Noda. University of California, Los Angeles, Department of Ecology and Evolutionary Biology, Box 951606, 621 Charles E. Young Dr. South, Los Angeles, CA 90095

Potamopyrgus antipodarum are small, dark colored, dextrally spiraled, aquatic mudsnails (Family: Hydrobiidae) native to New Zealand. They have a brood pouch (distinguishing them from the other two species of *Potamopyrgus*), tolerate a wide range of water temperatures and salinities, reproduce parthenogenetically, and have an operculum which allows them to survive up to 30 days out of water in a damp environment. It is known that *P. antipodarum* have established populations in Australia, Tasmania, most European countries, and the United States. Data collected from nine sites in the Upper Owens River Watershed from May through November 2002, showed that *P. antipodarum* were the dominate macroinvertebrate at some sites with densities greater than 700,000 per m^2 and comprised over 99% of the benthic macroinvertebrate fauna. *P. antipodarum* were present in low densities in May and increase through summer and early fall. At the site with the highest *P. antipodarum* density, individuals of reproductive size were present and young were being recruited in each month, May through November 2002.

3. MUDSNAILS INVADE THE 'BU: A CASE STUDY IN INSTITUTIONAL RESPONSES TO INVASIONS

D.M. Tamanaha and J.R. Topel. Santa Monica Bay Restoration Commission, 320 West 4th St., Suite 200, Los Angeles, CA 90013

In May 2006, New Zealand mudsnails, *Potamopyrgus antipodarum*, were discovered during routine macroinvertebrate monitoring in Malibu Creek, located in the Santa Monica Mountains of Southern California. We describe the initial discovery of *P. antipodarum*, and agency efforts to determine the extent of and response to the invasion. We also discuss the need to manage the threat invasives pose in a more holistic manner, rather than applying a species-by-species approach. Finally, we present a brief overview of invasive species management actions and discuss some of the challenges to implementation.

Agencies were able to coordinate and implement a rational, rapid response to the invasion including (1) a "mudsnail summit" to develop coordination between agencies, (2) a 44-site survey to determine the extent of the invasion, (3) a literature review on mudsnails, and (4) the development of a unified education and outreach effort. It is clear that the ability of agencies to coordinate their actions, efforts, and resources is a key factor in the *rapid* response to an invasion. Now that *P. antipodarum* has become established in the Malibu Creek watershed, continued management will require on-going monitoring, education, and research.

This episode has made it clear that managing invasives post- establishment is inadequate. The investment of time and resources necessary to implement on-going monitoring, education and control measures on a species-by-species basis is neither effective, nor efficient. Management must begin with stopping potential invasions before they occur, specifically by managing the pathways of introduction. Additionally, recognizing that despite our best efforts invasions will occur, we must make early detection of invasives an integrated part of habitat monitoring and restoration efforts.

4. DEVELOPMENT OF BIOLOGICAL CONTROL FOR THE NEW ZEALAND MUD SNAIL

T. Dudley[1], K.D. Lafferty[2,1], **B.L. Fredensborg**[1], and A.M. Kuris[3,1]. [1]Marine Science Institute; [3]Department of Ecology, Evolution, and Marine Biology; [2]US Geological Survey, Western Ecological Research Center; [1,2,3]University of California, Santa Barbara, CA 93106

The New Zealand Mud Snail (NZMS; Hydrobiidae: *Potamopyrgus antipodarum*), is spreading to streams, rivers and other water bodies across the western region of the U.S. The NZMS can interfere with aquatic invertebrates (including federally listed species), anadromous salmonids, and other fish dependent on invertebrates as resources. We propose to investigate biological control of NZMS by a specialized castrating trematode parasite, *Microphallus* sp. This could be a safe, sustainable and cost-effective means to suppress NZMS abundance in infested waters and to reduce the risk of further invasion. *Microphallus* sp. is a promising control agent for NZMS because: 1) It castrates the host, and enhances mortality through behavioral changes that increase susceptibility to avian predators. 2) *Microphallus* shows an extremely high host specificity and local adaptation to clones of snail hosts, which reduces the risk of infection in non-target species. Our evaluation of *Microphallus* sp. as a biocontrol agent for NZMS in the U.S. will include: 1) Developing demographic models to characterize relationships between *Microphallus* infection and NZMS abundance and reproduction in Australasia (source of snail and parasite), 2) Determining infectivity and efficacy of *Microphallus* to North American NZMS populations, and 3) Evaluating host specificity using host-range tests with non-target North America mollusks and potential impacts on avian hosts. The development of an effective and politically-acceptable biological control program will require several years of testing and evaluation before it can be implemented in the field. Thus, it is critical that a control program be evaluated very soon, before NZMS infestations dominate benthic assemblages throughout North America.

5. EFFECTS OF URBANIZATION ON THE DISTRIBUTION AND ABUNDANCE OF AMPHIBIANS AND INVASIVE SPECIES IN SOUTHERN CALIFORNIA STREAMS

Seth P.D. Riley[1], **Gary T. Busteed**[1], Lee B. Kats[2], Thomas L. Vandergon[2], Lena F.S. Lee[1], Rosi G. Dagit[3], Jacob L. Kerby[1,3,5], Robert N. Fisher[4], and Raymond M. Sauvajot[1]. [1]Santa Monica Mountains National Recreation Area, National Park Service, 401 W. Hillcrest Dr., Thousand Oaks, CA 91360; [2]Department of Biology, Pepperdine University, 24255 Pacific Coast Highway, Malibu, CA 90263; [3]Resource Conservation District of the Santa Monica Mountains, 122 N. Topanga Canyon Blvd., Topanga, CA 90290; [4]U.S. Geological Survey, San Diego Field Station, 5745 Kearny Villa Drive, Suite M, San Diego, CA 92123; [5]Environmental Science and Policy, 1 Shields Ave., University of California, Davis, CA 95616

Urbanization negatively affects natural ecosystems in many ways, aquatic systems in particular. Urbanization is also cited as one of the potential contributors to recent dramatic declines in amphibian populations. However, few field studies have examined amphibian communities in urban areas, and virtually none have addressed urbanization and stream amphibians. From 2000–2002, we determined the distribution and abundance of native amphibians and exotic predators and characterized stream habitat and invertebrate communities in 35 streams in an urbanized landscape north of Los Angeles. We measured watershed development as the percentage of area within each watershed that was occupied by urban land uses. Streams in more developed watersheds often had exotic crayfish (*Procambarus clarkii*) and fish and had fewer native species, such as California newts (*Taricha torosa*) and California treefrogs (*Hyla cadaverina*). These effects seemed to be particularly evident above 8% development, a result coincident with other urban stream studies that show negative impacts beginning at 10–15% urbanization. For Pacific treefrogs (*Hyla regilla*), the most widespread native amphibian, abundance was lower in the presence of exotic crayfish, although direct urbanization effects were not found. Faunal community changes in urban streams may be related to changes in physical stream habitat such as increased water depth and flow, leading to more permanent streams. Variation in stream permanence was particularly evident in 2002, a dry year when many natural streams were dry, but urban streams were relatively unchanged. Urbanization has significantly altered stream habitat in this region and may enhance invasion by exotics and negatively affect diversity and abundance of native amphibians.

6. AMPHIBIAN LIFE IN RESPONSE TO THE ACTIVE REMOVAL OF EXOTIC SPECIES IN STREAMS OF THE SANTA MONICA MOUNTAINS

L. Kats, S. Rollert, T. Thurling, **S. Landis**, and D. Cho. Pepperdine University, Department of Biology and Behavioral Ecology, Malibu, CA 90263

Exotic species have been shown to negatively impact stream-breeding amphibians in the Santa Monica Mountains. The exotic red swamp crayfish (Procambarus clarkii) for example have been known to eat amphibian eggs and larvae and have also been known to attack adult amphibians. For the past four years, we have been intensively trapping the exotic red swamp crayfish in an attempt to help native stream-breeding amphibians regenerate their populations. Due to overall stream size, the total removal of crayfish was unrealistic in our short-term expectations. As a result of this, we focused on the removal of crayfish from habitats that appeared to be optimal for amphibian breeding. Throughout the course of our project, over four thousand crayfish were trapped and removed. We also surveyed amphibians throughout the year and have collected data that has enabled us to compare pre-trapping surveys to those that were conducted during and after the four-year removal effort. The California newt (Taricha torosa) has long generation gaps making it increasingly difficult to determine the effectiveness of trapping exotic species in short term periods. The California tree frogs (Hyla cadaverina), however, have much shorter generation times allowing us to use the Hyla cadaverina as a way to measure amphibian health in the stream. Because of this, our research suggests that Hyla cadaverina numbers have increased significantly both during and after years when crayfish were intensively trapped.

7. CALIFORNIA RESPONSE TO THE DISCOVERY OF QUAGGA MUSSEL/ ZEBRA MUSSEL IN LAKE MEAD

S.R. Ellis. California Department of Fish and Game, Habitat Conservation Branch, Sacramento, CA 95814

On January 6, 2007, Quagga mussel was discovered in Lake Mead, NV. The State of California responded by establishing a formal Incident Command System. The Departments of Fish and Game, Food and Agriculture, Water Resources and Boating and Waterways partnered with the U.S. Fish and Wildlife Service, Metropolitan Water District and San Diego Water Authority in this effort. Surface and dive surveys commenced immediately in southern California and adult Quagga mussels were found in Lake Havasu and in the Colorado River Aqueduct. Border check stations at Yermo, Needles and Vidal Junction have increased operating hours to 24/7 to inspect all boats originating in Lakes Mead, Mohave and Havasu. In order to maximize effectiveness, a Science Advisor was appointed, and a Scientific Advisory Panel was convened to discuss eradication potential and options, containment strategies, and long term detection and monitoring needs. Numerous outreach materials have been developed and distributed to boaters and other stakeholder groups, including a letter to all registered boaters, establishment of a hot-line, boat cleaning guidance flyers and warning posters.

State agencies have maintained contact with the National Park Service to stay abreast of activities in Lake Mead, and provide boater survey information collected from infested boats entering California. Approximately $2.5 million has been dedicated to the first 6 months of this effort.

8. DISTRIBUTION, HABITAT UTILIZATION, AND REPRODUCTIVE PATTERNS IN *CAULACANTHUS USTULATUS* (CAULACANTHACEAE, GIGARTINALES), A NEWLY ESTABLISHED SEAWEED ON SOUTHERN CALIFORNIA SHORES

K.E. Whiteside, J.R. Smith, and S.N. Murray. California State University, Fullerton, Department of Biological Science, Fullerton, CA 92834

Southern California rocky intertidal macrophytes have experienced dramatic shifts in community structure over the last several decades including the recent (1999) appearance of the red alga *Caulacanthus ustulatus*. This species had previously been reported in the Northeastern Pacific only in Baja California, San Francisco Bay, Washington, and British Columbia. Molecular studies indicate that specimens from Washington and southern California are identical to material from Asia, its native location, and from northern France where the species has been introduced. Its absence from previous surveys and its genetic affinity with Asian specimens suggests that southern California populations of *Caulcanthus* may not be indigenous. Focusing on southern California populations of *Caulacanthus*, the goals of this study were to determine its: 1) Bight-wide distribution 2) abundance and habitat utilization at two local sites, and 3) reproductive patterns. Our surveys and specimens obtained from colleagues revealed that *Caulacanthus* is widespread along the southern California mainland from Los Angeles County to San Diego Bay and on both Catalina and Anacapa Islands. Abundance sampling at two Orange County locations over the last four years has shown that *Caulacanthus* is confined to mid and upper intertidal habitats where it is a persistent contributor to cover in algal turf communities. *Caulacanthus* grows on a variety of substrata including rock, mussel and barnacle surfaces, turf-forming macro-algae, and rockweed bases. Examination of thalli from local sites revealed that the majority of *Caulacanthus* specimens are sterile but that tetrasporangial plants exist, suggesting that both vegetative and spore recruitment are likely mechanisms for dispersal.

9. MANAGING THE SPREAD OF AQUATIC NUISANCE SPECIES THROUGH HACCP PLANNING

Denise A. Walther. Non-native Invasive Species Program, U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Stockton, CA 95205

Hazard Analysis and Critical Control Point (HACCP) planning is a process used to identify pathways for the introduction of aquatic nuisance species (ANS) in natural resource management activities. The HACCP process is an important tool for agencies and organizations that have the potential to inadvertently move ANS from one watershed to another through their natural resource management activities. Developing an effective HACCP plan entails using a team approach to work through the 5 steps of HACCP planning—1) describe the activity, 2) identify potential hazards, 3) diagram the flow of steps for the activity, 4) fill out a hazard analysis worksheet, and 5) complete the HACCP plan form. The U.S. Fish and Wildlife Service provides training and technical assistance to natural resource managers for creating HACCP plans. Additional resources are available on the internet at http://www.haccp-nrm.org/, including a library of completed plans and HACCP Planning Wizard software.

10. PARASITES IN FOOD WEBS AS BIOINDICATORS OF ENVIRONMENTAL CONDITIONS

Kevin D. Lafferty. University of California, Santa Barbara, CA 93106

Parasites are more sensitive than commonly thought. Stressful conditions can decrease parasite diversity faster than host diversity. This is for a few reasons. Firstly, parasites can be sensitive to pollution and they can be lacking from contaminated areas. Secondly, parasites require abundant host populations, so over fishing or disturbance can reduce parasitism. Finally, parasites with complex life cycles are dependent on diverse food webs. Removal of top predators and other simplifications to food webs can reduce the diversity of parasite communities. Sometimes, parasites are easier to measure than host communities and can act as positive bioindicators of ecosystem complexity and health. We have developed this approach to help monitor local estuaries and feel it has promise for other systems as well.

11. RELATIONSHIPS BETWEEN ENDOHELMINTH ASSEMBLAGES OF FISH AND WATER QUALITY

C. Hogue. California State University, Northridge, Department of Biology, Northridge, CA 91330

Fish are often target species in environmental monitoring programs. To a lesser extent, parasites of fish have functioned as bioindicators of complex interactions between their hosts and the contaminants that they are exposed to in their habitat. I examined host-parasite systems in water bodies with varying levels of contaminants to assess the relevance of using endoparasites to monitor aquatic ecosystem health along with such traditional tools as water and sediment analyses, composition of the benthic infaunal community, and tissue analyses. I studied endohelminth assemblages of white croaker *Genyonemus lineatus* from Los Angeles Harbor and Pacific sanddab *Citharichthys sordidus* from Santa Monica Bay. Data on helminth populations infecting these fishes are presented relative to levels of contaminants known in the habitat of their hosts. My findings suggest that negative impacts of contaminants on invertebrate host communities can contribute to the lower abundance of helminths infecting fish from more polluted habitats. One cestode species, *Lacistorhynchus dollfusi* showed potential as a bioindicator of pollution exposure in Pacific sanddab.

12. THE BIOMASS OF PARASITES AND THE ENERGETICS OF ECOSYSTEMS

Armand M. Kuris. University of California, Santa Barbara, CA 93106

To resolve the paradox that parasites have strong impacts to ecosystems, despite their apparent small biomass, we quantified the biomass of free-living and parasitic species in three Pacific Coast estuaries. Parasite biomass is unquantified in nature. 147 parasite species comprised 0.1 to 1% of the total animal biomass. While this seems small, parasite biomass exceeded that of important groups, such as birds, fishes, shrimp, or polychaetes. The biomass controlled by parasitic castrators sometimes exceeded that of their uninfected hosts. The annual productivity of the largest component of parasite biomass exceeded standing crop biomass by 3× and exceeded that of birds 3–10×. These results suggest that the effect of parasites on ecosystems may result from a surprisingly large biomass relative to their high trophic level.

13. FISH PREDATION ON TREMATODE CERCARIAE IN A CALIFORNIA ESTUARY

Amber T. Kaplan, Sayward E. Halling, Kevin D. Lafferty, and Armand M. Kuris. University of California, Santa Barbara, CA 93106

In salt marsh ecosystems where the snail *Cerithidea californica* is infected with digenean trematodes, billions of cercariae are shed into the estuary every day. But, a large percentage of cercariae do not reach their second intermediate hosts. Cercarial mortality factors are little studied and the role of predators as a mortality source is unknown. Our laboratory studies indicate that several zooplanktivorous fishes are potential predators. Seven local estuarine fish species were brought into the lab and offered cercariae from twelve trematode species that reside with them in the marsh. Thirty minutes after the fish were presented with cercariae, they were examined for the presence of cercariae in the gut. Most of these fishes rapidly engorged on cercariae. We also examined the relationship between the size of these fishes and cercarial feeding behavior. The species of fishes that preyed on cercariae in the lab were then examined in the field. We collected juvenile fishes form very shallow water on the rising tide. Cercariae are released from snails under these conditions. Fishes were dissected in the field to look for the presence of cercariae in their guts. Out of approximately 70 fish dissected in the field, three had cercariae in their foregut, specifically in the esophagus. The role of fishes as predators of cercariae and the actual biomass the cercariae contribute to the food webs of these estuaries will be discussed.

14. DEVELOPMENT OF *ASCAROPHIS* SP. (NEMATODA: CYSTIDICOLIDAE) TO MATURITY IN *GAMMARUS DEUBENI* (AMPHIPODA)

R.G. Appy. Port of Los Angeles, Environmental Management Division, San Pedro, CA 90371

Parasitic nematodes of the Order Spirurida are with some rare exceptions, heteroxenous; adult worms are present in a vertebrate host and infective third-stage larvae develop in various arthropods. An exception is *Ascrophis* sp. (Cystidicolidae), which is present as an adult in the hemocoel of the intertidal amphipod *Gammarus deubeni* found in Passamaquoddy Bay, New Brunswick, Canada. *Ascarophis* sp. is similar in morphology to *A. arctica*, which is found in the stomach of marine fish of Passamaquoddy Bay, and has been found as an adult in *G. oceanicus* in the Baltic Sea. In experimental infections of *G. deubeni*, first stage larvae penetrate host muscle and molt twice to become third stage larvae. Third stage larvae either remain in the muscle or move into the hemocoel where they molt twice and become adult worms. At 10–12°C gravid female worms are present at 80 days post-infection. Intestinal lumens of adult worms include host lipid deposits and hemocytes. Host hemocyte congregations are present on shed cuticles, *Ascarophis* eggs, and in some cases adult worms were found dead surrounded in melanin-like deposits. The direct development of *Ascarophis* in the invertebrate host may be "extreme precocity," (Anderson and Bartlett 1993), which is thought to enhance transmission when there is little time for parasite development in the definitive host. However, in experimental conditions, second generation juvenile *G. deubeni* have become infected, possibly through consumption/cannibalism of infected amphipods, suggesting that the definitive fish host may no longer be needed for parasite transmission.

15. PARASITE MANIPULATION OF BRAIN MONOAMINES IN KILLIFISH

J.C. Shaw[1], W.J. Korzan[2], R.E. Carpenter[3,4], A.M. Kuris[1], K.D. Lafferty[5], C.H. Summers[3,4], and Ø. Øverli[3,4,6]. [1]Department of Ecology, Evolution and Marine Biology, University of California Santa Barbara, CA; [2]Stanford University, Stanford, CA; [3]Biology; [4]Neuroscience Group, Division of Basic Biomedical Sciences, University of South Dakota, Vermillion, SD; [5]USGS, University of California Santa Barbara, CA; [6]Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, N-1432 Aas, Norway

Trematode parasites (*Euhaplorchis californiensis*) encyst around the brains of their second intermediate hosts, California killifish (*Fundulus parvipinnis*). As a result, infected fish display conspicuous swimming behaviors, such as flashing and surfacing, which increase their predation by avian definitive hosts. Yet the neuroendocrine mechanisms that drive these behavioral changes remain a mystery. Monoamine neurotransmitters such as dopamine (DA) and serotonin (5-HT) regulate many social and locomotory behaviors in fishes. We used micropunch dissection and HPLC to analyze concentrations of 5-HT, DA and their metabolites 5-hydroxyindoleacetic acid (5-HIAA) and 3,4-dihydroxyphenylacetic acid (DOPAC) in the brains of uninfected, naturally infected and experimentally infected fish. We measured monoamine activity (calculated as the ratio of monoamine to metabolite) in the hippocampus, striatum, hypothalamus and raphe nuclei. DA and 5-HT activity differed between uninfected and infected killifish overall, supporting our hypothesis that *E. californiensis* may alter brain monoamines to modify host behavior. Moreover, all four brain regions showed metacercarial density-dependent changes in monoamine activity in both experimentally and naturally infected fish (Table 1). In particular, high parasite density was associated with increased DA activity in the hypothalamus and decreased 5-HT activity in the hippocampus and raphe nuclei. Furthermore, a strong correlation appeared between increasing parasite density and decreasing raphe 5-HT activity in infected fish. Altered monoamine activity in these 3 brain regions could result in modified social and locomotory behavior in infected killifish.

16. THE INFLUENCE OF ECTOPARASITES AND WASTEWATER DISCHARGE ON THE ENDOCRINE STRESS RESPONSE IN MARINE FISHES

J.E. Kalman, **J.A. Reyes**, J.L. Armstrong, K. Sak, and K.M. Kelley. California State University, Long Beach, CA; Orange County Sanitation District, Fountain Valley, CA

The southern California marine environment is subjected to numerous inputs of pollution, and little is known about pollution effects on infestation of parasites on marine fishes. Poor water quality and pollution exposure can be chronic stressors, potentially decreasing a fish's defense system and increasing its susceptibility to diseases and parasites, while disease and/or parasitic infestation can potentially further exacerbate the stressed condition. Pollutants may also have direct effects upon several targets along the neuroendocrine hypothalamo-pituitary-interrenal (HPI) axis, affecting production of the stress hormone, cortisol. We evaluated marine fish (in particular California scorpionfish, *Scorpaena guttata*) and their associated parasites as potential bioindicators of environmental stress, and also assessed the ability of the HPI axis to normally respond to delivered stressors. Fish were collected by otter trawl from stations adjacent to and away from the Orange County Sanitation District (OCSD) outfall, blood was collected (and stored at −80°C until assayed for cortisol), and fish were frozen and later inspected for ectoparasitic infestation. Interestingly, when sampled from locations in the vicinity of the OCSD outfall, fish exhibited relatively higher parasite prevalence coincidentally with significantly impaired function of their HPI axis, as they could not produce normal surges in cortisol in response to catching stress.

17. THE EFFECTS OF THE ECTOPARASITIC ISOPOD *ELTHUSA CALIFORNICA* ON THE RESPIRATION OF THE SURF PERCH *CYMATOGASTER AGGREGATA*

H.D. Johnston, E. Guirges, and E.N. Kageno. University of California, Los Angeles, Department of Evolutionary and Ecological Biology, Los Angeles, CA 90024

Elthusa californica is an ectoparasite that resides in the gill cavity of *Cymatogaster aggregata*, and feeds off of the gill filaments to consume the blood that flows through the gills. Literature on the effects of the parasite and the stress it causes the host is lacking, therefore, this study quantifies the consequences of parasitism on the respiration rate of *Cymatogaster aggregata.* The fish were tested in five groups: fish with no isopods, fish with 1 isopod left on, fish with 1 isopod taken off, fish with 2 isopods left on, and fish with 2 isopods taken off. Each group of *Cymatogaster aggregata* was tested in ambient, 10%, and 5% oxygen concentrations where the amplitude of the mouth and the frequency of the opercular beats were observed. Gills were extracted to quantify gill damage, which was then correlated to the respiration rates. Regression tests demonstrated that this correlation had no significant difference between the five groups tested. This indicates that parasitism does not cause an intolerable amount of stress during respiration.

18. HISTORIC MERCURY DEPOSITION WITHIN THREE SOUTHERN CALIFORNIA SITES

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Mercury is a naturally occurring element in the earth's crust and may be released through natural sources, such as volcanic eruptions, or through anthropogenic activities, including gold mining, biomass burning, and coal-burning power plants. Once emitted into the environment, mercury may be transformed into methylmercury, the toxic form of mercury that is biomagnified in the aquatic food web. In the U.S., mercury is one of the most ubiquitous pollutants; 44 states and one territory report fish consumption advisories for mercury in at least one water body, including several sites in southern California. Despite the importance of mercury contamination to local watersheds, the relative abundance and magnitude of long- and short-range mercury sources are unknown. To address this question, historic mercury deposition was analyzed in dated sediment cores from three southern California sites: Mugu Lagoon (a coastal estuary in Ventura county), Big Bear Lake (a recreational lake in San Bernardino county) and Crystal Lake (a natural lake in the San Gabriel mountains). Potential sources of mercury varied between sites: urban runoff was the dominant mercury transport mechanism in Mugu Lagoon, while emissions from a cement factory in Big Bear Lake were correlated with increased mercury levels, and in Crystal Lake mercury peaks were associated with historic fires. In all three sites, mercury was positively correlated with organic content (Mugu Lagoon, r=85%; Big Bear, r=75%, Crystal Lake: r=60%), creating a long-term reservoir for mercury in each site, which may be methylated and magnified in fish tissue for many generations.

19. HIGH-RESOLUTION THIN-SECTION PHOTOMICROGRAPHY ANALYSIS OF A GLACIAL-AGE SEDIMENT CORE FROM BALDWIN LAKE, SOUTHERN CALIFORNIA: A LOOK AT SOME INITIAL RESULTS

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Digital image analysis of thin-section photomicrographs allows an "*in situ*" high-resolution study of lake sediment textures and types. A micro-sedimentological and high-resolution digital gray-scale imagery analysis of drill core (BLDC04-2) from Baldwin Lake, Southern California, is used to investigate variations between massive and laminated sediment units as well as to examine sediment contacts. Study of thin-sections from massive sediment units reveal a heterogeneous sediment fabric lacking any distinct structures or textures. Surprisingly, the thin-sections from the laminated sediment units also lack any distinguishable features. Sediment contacts are typically marked by gradual to sharp changes in sediment color. Conversely, gray-scale digital image analyses of the sediment thin-sections show a high degree of variability within both the massive and the laminated sediment units. This variability will be explored using wavelet time-series analysis of the grayscale data to investigate the potential relationship between lake sedimentation and climate forcing (e.g., ENSO, PDO, solar forcing). Gray-scale analysis shows that sediment contacts are characterized by sharp to gradual shifts in values.

The results obtained from this study will be compared with high-resolution grain-size data, magnetic susceptibility, and loss on ignition data. Using these sediment analyses, we aim to answer several questions: 1) what is the process of sedimentation during massive and laminated units; 2) is there a sediment-climate connection; and, 3) how does our interpretation fit with existing sediment studies from arid environment lakes.

20. THE PALEOENVIRONMENT OF BURGESS SHALE-TYPE DEPOSITS: FROM SOUTHERN CALIFORNIA TO SOUTH CHINA

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Burgess Shale-type (BST) deposits preserve "soft", nonmineralized tissues in addition to the shells, teeth and bones of which the fossil record is almost exclusively comprised. For this reason, they offer a remarkable window on the "Cambrian Explosion", the initial Phanerozoic radiation of the metazoa that defines the Neoproterozoic-Cambrian transition, and their biotas form the foundation of large scale evolutionary and ecological models. Clearly, BST deposits represent significant and unexplained deviations from the constraints that govern the typical operation of the fossil record. Microstratigraphic investigation of Early and Middle Cambrian BST deposits of western Laurentia and south China indicates that BST deposits occurred at discrete loci only when a specific set of paleoenvironmental criteria was satisfied. Constraints of the physical depositional environment exerted a primary control: BST intervals occur in a specific physical depositional window at the distal margin of scour, where re-working was absent, yet deposition was event-driven and rapid, and consisted of exclusively fine-grained sediments (<30 μ). Within this favorable physical environment, the chemistry of the benthic environment exerted the next important control, with exceptional fossilization occurring only under anoxic benthic conditions. Finally, the mineralogic and ionic composition of sediments and porewaters, and sediment permeability determined what microbial reactions were favored and the extent to which each could progress. These results suggest that BST deposits represent a single phenomenon that was regulated by microenvironmental parameters.

21. LATE QUATERNARY VEGETATION HISTORY OF THE MOJAVE COLORADO DESERT ECOTONE AT JOSHUA TREE NATIONAL PARK

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Much of what is known about the vegetation history of semi-arid North America comes from the analysis of fossil (*Neotoma*) packrat middens, with a surprising number of these studies conducted in National Parks. Midden researchers have tended to work in National Parks, not only because of their biodiversity, protected status, and accessibility, but also because the Parks have the infrastructure to readily broadcast novel research results to both the scientific and lay public. However, the region in and around Joshua Tree National Park (JTNP) in southern California, USA represents a conspicuous gap in midden coverage. This study represents the first paleovegetation record for JTNP and helps to fill a gap in our knowledge of the vegetation history of the southwestern United States in response to late Quaternary climate change. Macrofossil analysis of 34 middens collected from upper desert elevations (930–1360 m) provides a record of vegetation change along the Mojave-Colorado Desert ecotone spanning the last ~34,000 years. Late glacial assemblages were dominated by *Juniperus osteosperma*, *Juniperus californica*, *Pinus monophylla*, *Quercus cf. john-tuckeri* and *Quercus cf. turbinella* with an understory of *Cercocarpus ledifolius* var. *intermontanus*, *Purshia tridentata* var. *glandulosa*, *Artemisia bigelovii/tridentata*-type, *Encelia*, *Ericamerica cuneata* var. *spathulata*, *Peucephyllum schotti*, and *Yucca brevifolia*. Several of these species are present at the site today, reflecting considerable stability in the flora. Ten samples dating from 13,880 to 8480 cal years BP document changes associated with the glacial-interglacial transition. This period is marked by the arrival of several new species including *Prunus fasciculata*, *Rhus*, *Acacia greggii*, and the grasses *Bothriochloa barbinodis*, *Bouteloua barbata*, *Bouteloua* cf. *curtipendula*, and *Bouteloua* cf. *gracilis*. During the middle Holocene (8000–4000 cal yr BP) *J. osteosperma*, *Cercocarpus ledifolius* var. *intermontanus*, and *Purshia tridentata* disappear and are replaced by increasingly xeric-adapted species including *Ambrosia ilicifolia*, *Lycium*, *Larrea tridentata*, *Simmondsia chinensis*, *Coleogyne ramisissima*, and *Chenopodium*, indicative of a trend towards increased aridity.

22. CONTEMPORARY WATER QUALITY AND SEDIMENT PROPERTIES OF SOUTHERN CALIFORNIA LAKES

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Lakes are critical resources in Southern California, serving as habitat for a wide array of species, providing recreational opportunities for the region's vast population, and playing key roles in flood control and water supply. Agricultural, industrial, municipal and urban/suburban development in the region has altered the characteristics of the watersheds, streams and lakes, however. This study will summarize water quality in a number of lakes in Southern California, with particular emphasis on sediment properties, the release of nutrients from sediments via internal recycling, and the role that nutrient release from sediments plays in lake nutrient budgets.

23. FLOODS, FIRES, AND HUMANS: ASSESSING 150 YEARS OF RAPID DEPOSITIONAL EVENTS IN A SMALL ALPINE LAKE, SOUTHERN CALIFORNIA

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Sediments from a small, natural alpine lake in Southern California are examined to test the hypothesis that large, flood-producing precipitation events generate distinct sediment layers. If validated, a record of paleo-storm activity for Southern California can be reconstructed using longer sediment records. A variety of sedimentological analyses indicate that 6 rapidly deposited layers (RDL's) were generated over the past 150 years. Although these six layers contain similar characteristics, they cannot be explained by simple comparison to historic precipitation or river discharge records. A more detailed investigation of human and fire activity over the past 150 years in the drainage basin indicates that other disturbances besides large, flood-producing precipitation events can generate similar sediment layers. In fact, four of the six rapidly deposited layers are associated better with human and fire activity than large, flood-producing precipitation events. These results show that caution must be used when assigning historic-age RDL's to flood events. Without considering the impact of human and fire activity, in the appropriate environment, researchers may misinterpret the mechanisms, which pre-condition the substrate for increased susceptibility to erosion such as human disturbance and fire activity.

24. RECONSTRUCTING LATE PLIOCENE TO MIDDLE PLEISTOCENE DEATH VALLEY LAKES AND RIVER SYSTEMS AS A TEST OF PUPFISH (CYPRINODONTIDAE) DISPERSAL HYPOTHESES

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During glacial periods, Death Valley was the terminus for the Amargosa, Owens and Mojave Rivers. Geological and biological studies tend to support this along with a hydrologic link to the Colorado River that allowed pupfish dispersal throughout southeastern California and western Nevada. Recent mDNA studies support a common regional pupfish (*Cyprinodontidae*) ancestry that diverged 3–2 Ma. Tephrochronologic and paleomagnetic data are presented to test the paleohydrologic connections with respect to Death Valley during successive glacial periods: (1) the late Pliocene to early Pleistocene, (2) early-middle Pleistocene, and (3) middle to late Pleistocene. We conclude that 3–2 Ma a narrow lake occupied the ancient Furnace Creek basin and that Death Valley was not hydrologically connected with the Amargosa or Mojave Rivers. Paucity of data does not allow us to evaluate an Owens River connection to Death Valley 3–2 Ma. Previous studies show that Death Valley was not hydrologically linked to the Amargosa, Owens or Mojave Rivers 1.2–0.5 Ma. No evidence was found that Lake Manly backflooded up the Mojave River 0.18–0.12 Ma, although surface water flowed from the Amargosa and Owens Rivers to Death Valley at this time. A hydrologic link to the Colorado River in the last 3–2 m.y. was not found. Therefore, the hypothesis that pupfish dispersed or were isolated by severed paleohydrologic connections is not supported; however, sparse and disputed data suggest a fluvial system connected Panamint (Owens River), Death, and Amargosa valleys before 3 m.y. ago.

25. ON-GOING PALEOENVIRONMENTAL STUDIES ON LAKES FROM CENTRAL CALIFORNIA

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Work in progress is presented for three lakes occupying two drainage basins in Central California. The most mature study entails the testing of a recently published, Holocene lake-level history from Tulare Lake, a lake fed by major rivers sourced in the high elevation, southern Sierra. New data are presented here from cores acquired in the Summer of 2005. Samples were taken at 1 cm intervals and analyses include total organic and inorganic carbon analysis (loss-on-ignition method), magnetic susceptibility, and ostracode paleontology. Initial results support the published model; deeper lakes occurred in the early Holocene (low TOC) and the later Holocene was characterized by shallower lake levels (higher TOC with frequent large excursions from the mean value). Initial paleontological results from Buena Vista Lake, a lake higher up in the same drainage system, support earlier hypotheses of a much wetter, colder San Joaquin Valley during pluvial episodes over the past several hundreds of thousands of years, including intervals when fir may have grown on the valley floor. A 40 m core was taken from North Soda Lake basin in the Carrizo Plain. This core will potentially yield a paleoenvironmental record representing a very small drainage basin in the California Coast Ranges at a latitude of ~35.2°N and longitude of 119.9°W. Unlike Tulare and Buena Vista Lakes, which sample essentially the same precipitation source as Owens Lake and Searles Lake, the Carrizo Plain core will represent a heretofore unsampled geographic region between the Sierra Nevada and the Pacific Ocean.

26. LATE PLEISTOCENE PLUVIAL LAKES OF THE OWENS RIVER CASCADE, CALIFORNIA: THE RELATIVE ROLES OF TECTONIC AND CLIMATIC FORCING

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Pluvial lakes in the American West commonly occupy broad epeirogenic downwarps or narrower graben. These lakes flourished during the colder wetter climates of Pleistocene cold stages, only to shrink and often desiccate during warmer drier phases, most recently during Holocene time. Both tectonism and climate have thus influenced lake behavior. However, because tectonic activity becomes more apparent over longer timescales (10^3–10^7 years) whereas climate changes function over shorter timescales (10^1–10^5 years), it is usually assumed that climate is the main driver of these lakes and that changes in lake volume are driven by climate cycles, as deduced independently from ice-cores and marine archives. The tectonic setting of pluvial lakes, with certain exceptions, is usually considered invariant within these shorter timescales. From our continuing research at Owens Lake, however, we suggest that tectonic events operating over intermediate timescales (10^3–10^5 years) have had significant impacts on late Pleistocene events. The Owens River cascade, traditionally viewed as a climate-driven system within an established tectonic framework, contains lakes and linkages that have been measurably changed by magmatic forcing and massive faulting within the past 10^3–10^5 years, and sometimes more rapidly. The evidence derives from deformed late Pleistocene shorelines and spillways that carried overflow waters southward to Searles Lake and beyond. Tectonic forcing within this time frame altered lake capacity, geochemistry, geomorphic processes, and sedimentation. Thus tectonism and climate are interactive drivers of lake change and the playing field on which climate exerts its influence is by no means stable.

27. LATE PREHISTORIC HUMAN IMPACTS ON MARINE FAUNA IN SOUTHERN CALIFORNIA: AN EXAMPLE FROM SAN NICOLAS ISLAND IN THE SOUTHERN CHANNEL ISLANDS

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Paleontological, archaeofaunal, and other scientific studies conducted during the past few decades show that ancient humans substantially impacted the ecology of many islands in the world. The recognition of these anthropogenic environments in the archaeological record has been masked over the years by the perceptions of some researchers that prehistoric Holocene environments contained an abundance of "pristine" faunal resources in which native peoples were the stewards of the land, and that animal extinctions and extirpations only occurred in the late historic period after Euro-American settlement of these islands. San Nicolas Island in the Channel Islands off the coast of southern California is no exception to this pattern. Human habitation on the island spans over 7,000 years of prehistory, which had a substantial impact on the environment. Data from several archaeological sites occupied during the last two thousand years of the late Holocene are examined with regard to overexploitation and resource depression of marine mammals, fish, and shellfish populations in near shore environments around the island. Results indicate that the prehistoric island inhabitants extirpated some marine mammals and substantially reduced the size of keystone mollusk species.

28. PREHISTORIC MARINE ADAPTATION AND POSSIBLE TRENDS OF OVEREXPLOITATION ON SAN NICOLAS ISLAND

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Archaeological evidence from San Nicolas Island suggests that the prehistoric inhabitants have had a long history of marine adaptation, beginning in the Middle Holocene. Since the first islanders, the people that occupied the island have been dependent on the local marine environment for survival. The archaeological record indicates that shellfish, Sea mammals, marine birds, and numerous species of fish were intensely exploited by the islanders. Applying optimal foraging theory as a base for interpreting the archaeological record from San Nicolas Island can help decipher possible trends of overexploitation of marine animals. Two archaeological sites will be intensely discussed to provide a synthesis for the relationships the islanders had with the marine environment.

29. FIXING THE LANDSCAPE IN PLACE: TAKIC PLACE NAMES AND NATURAL RESOURCES

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Native Americans filled the landscape with named places, including villages, natural features, gathering areas, and locations of important events. Place names used by several southern California tribes speaking dialects of the Takic languages are well known and provide numerous examples of naming places after natural resources found at those places. Names of economically useful plants are seen to dominate, along with names of animals and minerals. Examples given here are taken from the Acjachemen, Luiseño and Tongva tribes of south coastal California.

30. BURIED SITES ARCHAEOLOGY: LIFE BY THE LAKES IN LAGUNA CANYON DURING THE INTERMEDIATE AND LATE PREHISTORIC PERIODS

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People have been living by the lakes in Laguna Canyon, California for thousands of years, given the reliable availability of fresh water resources. The canyon is the only good travel route through the San Joaquin Hills, linking inland resource areas with the ocean. Recent construction exposed hearth features, artifact caches, and a dog burial. This paper will present in landscape context the results of excavations and scientific analyses of the data, including macro-botanical, geophysical, geomorphological, and radiocarbon studies. Issues of nomadism versus sedentism will be addressed. Additionally, the limitations of hand excavations in identifying deeply buried, low density, feature based sites will be discussed.

31. PREHISTORIC AND HISTORICAL ENVIRONMENT INTERACTIONS ALONG SANTA MONICA BAY, CALIFORNIA

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Human occupation along Santa Monica Bay dates back more than 8,000 years. Using archaeological, ethnographic, and archival data, we offer an overview of human interaction with the environment in this area from approximately 6,000 B.C. to A.D. 1940. For thousands of years, the area's Native American inhabitants followed a littoral adaptation to the Ballona wetlands and the surrounding coastal prairie that allowed the creation of a stable and conservative culture. The subtle changes in subsistence and settlement we have documented during this time were responses to regional climatic changes and the slowly evolving wetlands. With the arrival of the Spanish in the mid-1700s and their imposition of new technologies and economies on the landscape, the relationship between humans and the environment changed dramatically, making traditional Native American lifeways untenable. The later founding of ranchos and large land-grants in the area greatly altered the landscape and created new economies never seen before. Finally, the transition to the 20th Century began the slow, but steady growth of urbanization that we see now on the west side of Los Angeles.

32. UNDERSTANDING HUMAN RELATIONSHIPS WITH THE ENVIRONMENT THROUGH THE ANALYSIS OF ECONOMIC SYSTEMS DURING THE MIDDLE HOLOCENE IN THE NEWPORT BAY REGION

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The occurrence of cultural remains at CA-ORA-64, a Middle Holocene site located in Newport Bay, Orange County, California, raises many questions as to their origins and similarities with collections from other regions. This paper uses a micro and macro model to understand how socioeconomic trends represented by such artifacts also may provide information on how individuals living within the ORA-64 region interacted with their environment. This is done by addressing cultural remains and settlement patterns in association with climatic change. In addition, the model of hunter-gatherers as foragers and collectors defined by Mason et al. (1997) is used to understand the dynamics under which climate change and human use of resources affected continuous occupation or abandonment of sites, such as in the case of ORA-64.

33. TAPHONOMIC IMPLICATIONS OF DIFFERENTIAL PRESERVATION BETWEEN FRESHWATER FISHES

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The Sacramento perch, *Archoplites interruptus* (Centrarchidae), is the freshwater fish found in the greatest abundance in archaeological sites in the Central Valley of California. Native minnows

(Cyprinidae), not Sacramento perch, should be prominently represented, given the diversity of species. Due to this unexpected representation, I hypothesized that Sacramento perch bones may better resist decomposition in the soil and thus persist, while the bones of other freshwater species, such as minnows, decompose. To test this possibility, nine individual centrarchids and 20 individual cyprinids were buried in the soil for over seven years. The burial site was excavated, and the remaining bones were identified. Since vertebrae are among the most commonly preserved skeletal elements, particular emphasis was placed on their recovery. From comparison of recovered vertebrae and skull bones, it was found that the preservation of centrarchid elements was greater.

34. LONG-TERM ECOLOGY OF THE ICHTHYOFAUNA ADJACENT TO HUNTINGTON BEACH GENERATING STATION: A REVIEW OF ONCE THROUGH COOLING THEN AND NOW IN THE CONTEXT OF OCEANIC REGIME SHIFT

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Two intensive impingement studies at Huntington Beach Generating Station, separated by nearly 25 years, show a nearly seven-fold decrease in impinged abundance between 1978–1981 and 2003–2005 survey periods. Annual surveys since 1987 have documented continued decreases in impinged abundances through 2004 before increasing to near historic levels in 2005. Queenfish and white croaker comprised over 85% of the total impinged abundance. During the same period, average annual cooling water flows decreased from 476 million gallons in 1982 to 135 million gallons in 1991 before gradually increasing to 357 million gallons in 2005. Nearly annual otter trawl surveys show a similar decline in demersal fish abundance overall, although record densities were recorded in 1993. Overall annual trawl density was highly impacted by the abundance, or lack thereof, of white croaker. Similar studies have noted a decline in area fish stocks associated with the warm water regime that persisted from the late 1970's to the late 1990's. Lastly, the first site-specific ichthyoplankton survey of the area was conducted from 2003–2004, during which goby CIQ (*Clevlandia ios*, *Ilypnus gilberti*, and *Quietula y-cauda*) was the most abundant taxa, nearly doubling the density of the next most abundant group, unidentified anchovies (Engraulidae).

35. THE RECOVERING PACIFIC SARDINE (*SARDINOPS SAGAX*) POPULATION AS AN INDICATOR OF LINKAGE BETWEEN THE SOUTHERN CALIFORNIA BIGHT AND THE NORTH PACIFIC TRANSITION ZONE

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The recovery of the northern stock of sardine, *Sardinops sagax*, reminds us of how much biological and oceanographic research has been accomplished in the California Current while this stock was a virtual non-entity. It is the purpose of this study to update the ecology, oceanography and the human impacts on this species. Two sardine stocks, apparently isolated by spawning season and temperature, overlap in the Southern California Bight. The southern spawning stock, Cape San Lucas to Point Conception, spawns with the Panamic fauna in late summer: the northern spawning stock, Punta Eugenio to Alaska spawns in late winter-spring which is typical for the Oregonian fauna. By the end of the 1940's the northern stock was much reduced and virtually undetectable through the 1960s and 1970s while the southern stock apparently continued at about the same levels. Much research remains to be done to reincorporate this major player into its assemblages and the Northeast Pacific ecosystem.

36. CHLORINATED HYDROCARBONS IN PELAGIC FORAGE FISHES AND SQUID OF THE SOUTHERN CALIFORNIA BIGHT

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Large quantities of dichlorodiphenyltrichloroethane (total DDT) and polychlorinated biphenyls (total PCB) have been historically discharged to the southern California Bight (SCB). While these contaminants have bioaccumulated in sediment-associated fishes, little data exists on concentrations of these compounds in pelagic forage species that are the likely food source to larger predatory mammals and birds. The goal of this study was to assess the extent and magnitude of total DDT and total PCB bioaccumulation in the four major pelagic species of the SCB: Pacific sardine (*Sardinops sagax*), Pacific chub mackerel (*Scomber japonicus*), northern anchovy (*Engraulis mordax*), and California market squid (*Loligo opalescens*). A total of 99 composite samples were collected from commercial landing docks along the southern California coast from July 2003 to February 2004. Whole fish were homogenized and analyzed for total DDT (ortho- and para-isomers of DDT, DDE, and DDD) and 41 PCB congeners. Virtually all of the samples of Pacific sardine, northern anchovy, and Pacific chub mackerel had detectable levels of total DDT. Only 50% of the California market squid samples had detectable total DDT. Northern anchovy had the highest tDDT concentrations (60 ± 38 µg/kg wet weight [ww]), followed by Pacific chub mackerel (41 ± 40 µg/kg ww), Pacific sardine (34 ± 29 µg/kg ww), and California market squid (0.8 ± 1.2 µg/kg ww). In general, concentrations were highest in the central SCB. An estimated 99% of northern anchovy, 83% of Pacific sardine, 33% of Pacific chub mackerel, and 0% of California market squid landings exceeded wildlife risk screening values for total DDT. Virtually none of the landings were estimated to exceed wildlife risk screening values for PCBs.

37. VARIATION IN DDT/PCB CONCENTRATIONS IN WHITE CROAKER (*GENYONEMUS LINIATUS*) IN THE SOUTHERN CALIFORNIA BIGHT: INFLUENES OF LOCATION, BODY SIZE, AND LIPID CONTENT

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White croaker (*Genyonemus liniatus*) has received much attention in the Southern California Bight due to elevated PCB/DDT concentrations in their tissues in some areas within the bight. This contamination has resulted in fish consumption advisories for this species, particularly on the Palos Verdes Shelf and southern Santa Monica Bay. Few studies have examined in detail the spatial variation in PCB/DDT concentrations in white croaker, and no broad scale surveys have been conducted since 1987. We report results from a survey of contaminants in fish that examined contaminant concentrations in individual fish over a broad area of the bight. While the survey collected 23 species of fish, our discussion will be limited to results from white croaker, the species for which the most spatially comprehensive data were collected. Individual-level analyses allows for detailed evaluation of the effects of between location and between individual differences on PCB/DDT concentrations. Results of this analysis suggest that while location strongly influences contamination levels, individual differences, particularly lipid concentration, also play a role. The influence of factors such as lipid concentration, body size, and individual movement patterns may serve to either mask or falsely create differences between locations if not carefully evaluated, making the interpretation of contaminant data that is based on composites difficult. We argue that to most effectively evaluate spatial and temporal trends in contaminant concentrations, it is critical to analyze individuals and to record individual characteristics (size, lipid content, gender, etc) so that differences between locations and time-points can be distinguished from differences in these characteristics.

38. CONDITION OF DEMERSAL FISH AND INVERTEBRATE ASSEMBLAGES IN THE SOUTHERN CALIFORNIA BIGHT IN 2003

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A regional survey of the Southern California Bight in 2003 assessed the condition of demersal fish and invertebrate populations and assemblages, bioaccumulation in pelagic forage fishes, and the distribution of marine debris. The 210 stations at 2-476 m depth were sampled using 7.6-m wide otter trawls from Point Conception to San Diego and at the Channel Islands yielded 142 species of fish and 308 species of invertebrates. Fish and invertebrate assemblages were associated with bathymetric life zones, with islands differing slightly from the mainland. Population attributes varied most by depth, being lowest in bays or inner shelf and highest at middle and outer shelf zones. Compared to the 1970s, demersal fish and invertebrate populations and assemblages were relatively healthy in 2003. A fish biointegrity index assessment showed 96% of the area to be normal. Fish populations had background levels of anomalies and a baseline was established for fish ectoparasites. Anthropogenic debris increased from 14 to 25% of the shelf area since 1994. DDT was prevalent in pelagic forage fishes collected in the Bight in association with this survey. During the past regional surveys, fish and invertebrate assemblages have changed in time in response to the prevailing ocean climate during the survey. Depth displacement patterns in fish foraging guilds described during a cold regime in the 1970s were most similar to those of 2003 (also cold), least in 1998 (very warm), and intermediate in 1994 (warm). Future assessments must distinguish local anthropogenic effects from responses to naturally changing ocean conditions.

39. THE CONDITION OF BENTHIC INVERTEBRATE COMMUNITIES IN THE SOUTHERN CALIFORNIA BIGHT

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Benthic community condition in the Southern California Bight (SCB) was assessed for the Bight'03 Regional Monitoring Survey. In summer 2003, 351 benthic samples were collected in the SCB using a random tessellation stratified (RTS) design stratified on habitats and potential sources of pollution. Samples were collected with 0.1 m^2 Van Veen grabs and sieved through 1 mm mesh screens. Organisms retained on screens were identified and counted. The species abundances were used to assess community condition for each sample using the Benthic Response Index (BRI) on the mainland shelf and the SQO26 index in bays, harbors, and estuaries. Where possible, benthic conditions in 2003 were compared with conditions during similar surveys in 1994 and 1998. Overall, SCB benthos were in good condition during 2003, with 98.4% of the area in reference condition or only deviating marginally. There was no evidence of disturbance on the island shelf, near small POTWs, and virtually none on the mainland shelf. Areas near large POTWs did not differ substantially from other areas at similar depths on the coastal mainland shelf. Benthos in bays and estuaries were more frequently disturbed with altered benthic communities occupying nearly 13% of the area. Altered communities occurred most frequently in estuaries and marinas. The condition of benthos on the SCB mainland shelf is not changing rapidly with 1.6 to 2.8% of the coastal shelf remaining in poor benthic condition over the 9-year time span.

40. CHARACTERISTICS OF BENTHIC MACROFAUNA OF THE SOUTHERN CALIFORNIA BIGHT

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During summer and fall of three regional surveys between 1994 and 2003, sediments from eight Southern California Bight (SCB) habitats were collected with a 0.1 m^2 Van Veen grab, sieved through

a 1 mm mesh screen and analyzed for community characteristics. Among 977 samples, 413 were determined to be from areas that could be potentially contaminated. Among the remainder (564), habitat means were calculated for five community measures: total abundance, number of taxa, Shannon-Wiener diversity, evenness, and dominance. For habitats where data were available from multiple surveys, community measure means were also compared among the surveys.

Mean abundances of benthic macrofauna decreased with increasing distance from land. Taxa counts were highest on the shelf and were lower in both shallower and deeper habitats. Patterns for diversity and dominance mirrored taxa counts, but eveness values increased slightly with depth. When compared among surveys, community patterns were mostly stable and did not significantly change over time. The exception was the island shelf, where significant increases in diversity, evenness and dominance occurred from 1998 to 2003. Annelid abundances dominated all .benthic habitats (49%–63%). Very low proportions of these were oligochaetes, except in estuaries where they represented about one-quarter of all annelids collected. Mollusks and arthropods were typically ranked either second or third in abundance behind annelids except on the middle and outer shelves where ophiuroids ranked above mollusks. Data from this survey can be used as a baseline for all SCB monitoring programs.

41. MARINE ECOLOGICAL MONITORING STUDIES AT CRYSTAL COVE STATE PARK TO DETERMINE IMPACTS FROM A COASTAL DEVELOPMENT PROJECT

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Development of the marine terrace along the Newport Coast above Crystal Cove State Park was initiated in early 1990's. During Phase IV of this development project quantitative ecological field studies were carried out from December 1999 to May 2006 to evaluate possible effects of storm water runoff on intertidal and shallow subtidal marine invertebrates and algae. Study sites were adjacent to the mouths of three watershed drainages. At each site, photographs were taken before the start of the rainfall season and at a series of time periods after rainfall events or at the end of the rainfall season. Images were reviewed using Scion imaging software to quantify percent cover for selected species. Surf grass samples, *Phyllospadix torreyi*, were also collected in conjunction with this sampling and analyzed for percent cover of algal epiphytes and animal epibionts on the blades. Both multiple regression and BACI techniques were used to analyze the data. Results from template quadrat studies indicate clearly that lowered salinities and constituents in storm runoff at the rocky intertidal stations had no evident or statistically significant effects on percent cover of the indicator species *Anthopleura elegantissima* and *Mytilus californianus*. The same was true for density (number of individuals per 1000 sq cm) of *M. californianus*. Furthermore, the results of all the ecological studies indicate clearly that there were no evident or significant effects on the marine organisms of the Newport Coast due to runoff from storms.

42. MODIS IMAGERY AS A TOOL FOR SYNOPTIC WATER QUALITY ASSESSMENTS IN SOUTHERN CALIFORNIA COASTAL OCEAN

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The dynamics of rainstorm plumes in the coastal waters of southern California was studied during the Bight'03 Regional Water Quality Program surveys in February 2004 and February-March 2005. Measurements of surface salinity, concentrations of total suspended solids (TSS), colored dissolved organic matter (CDOM), and bacterial counts collected from research vessels were compared to simultaneously collected MODIS-Aqua satellite imagery. The spectra of normalized water-leaving radiation (nLw) were different in plumes and ambient ocean waters, enabling plumes discrimination and plume area size assessments from remotely-sensed data. The accuracy of plume area assessments from satellite imagery was not high, seemingly because of inexactitude in satellite data processing. In particular, the expected correlation between remotely-sensed CDOM absorption estimated by Lee's quasi-analytical algorithm (QAA) and CDOM concentrations in the water column was often obscured by external factors including wind-driven sea state and phytoplankton blooms. Nevertheless, satellite imagery is a useful tool for the estimation of the extent of polluted plumes, which is hardly achievable by contact methods.

43. SETTING UP A WATER QUALITY MONITORING NETWORK ALONG THE CALIFORNIA COASTLINE

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California State University (CSU) has established the Coastal Observation, Research and Education (CICORE) observatory. The purpose of this project is to gain a better understanding of how natural processes and human activities impact the coastal environment and to communicate this information to the scientific community, regional agencies, and the public. CICORE consists of eight CSU campuses. Each campus has set up or is in the process of setting up sites along the California coastline. Southern California Marine Institute (SCMI), through CSU Long Beach, is the CICORE contributor in the greater Los Angeles area. SCMI, has established a site at the terminus of the Los Angeles River and at Fish Harbor, in Los Angeles Harbor. Standard water quality measurements are collected and transmitted at six-minute intervals at a depth of 1.5 m from the surface. These measurements include pH, turbidity, temperature, chlorophyll *a* concentrations, salinity, and dissolved oxygen. This data is readily available in near real-time on the web (http://www.icontrol.ws/SCMI). Data presented here show the value of high frequency water quality monitoring in understanding the natural variability as well as the impacts detected from storm water and pollution events. The future goals of this project are to include weather stations at each site, to increase the number of sites to get a better overall picture of the measured parameters and to integrate these data with other regional and regulatory efforts.

44. CONTRASTING BASALTIC ERUPTION STYLES OBSERVED AT RED CONES, EASTERN SIERRA NEVADA

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Red Cones are a nested pair of basaltic cinder cones located approximately 10 km SW of Mammoth Mountain, in the eastern Sierra Nevada of California. Basaltic eruptions about 5,000 years began with violent Strombolian eruptions that formed the cinder cone pair followed by effusive eruptions of lava. Lava flows range from 0.1 to 2 m in thickness, and exhibit both aa and pahoehoe textures, as well as well preserved flow levees and lava tubes. The Red Cones eruptions were dominantly effusive, with variably fluid lava flows accounting for 90% of the total dense rock erupted material (1 cubic km). Cinder and lavas range narrowly in crystal content from 5 to 8 vol%, and contains plagioclase, olivine, clinopyroxene, and magnetite with traces of ilmenite. The finale of the eruption from the north cone was characterized by alternating explosive and effusive phases marked by spatter mounds enclosing the vent region, whereas the south cone shows no evidence of explosive activity at the eruptions end. In order to investigate the role that magma composition plays in this commonly observed temporal sequence of changing eruption styles as noted at other cinder cones, we are combining detailed geologic mapping with electron microbeam analysis of olivine, plagioclase, and Fe-Ti oxide phenocrysts from both cinder and lava products of Red Cones.

45. PETROLOGIC CONSTRAINTS ON ERUPTION TRIGGERING AT MAMMOTH MOUNTAIN, CALIFORNIA

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In this study, we present results that constrain the timescales of eruption triggering and magma ascent at Mammoth Mountain, a trachydacitic to rhyodacitic dome cluster located on the southwestern rim of Long Valley Caldera in eastern California. Field-based observations and analytical evidence show that many Mammoth Mountain dome magmas were repeatedly intruded by batches of mafic magma prior to eruption based on the presence of mafic enclaves, derivative xenocrysts, and disquilibria textures. Electron microprobe analysis touching Fe-Ti oxide pairs analyzed from 7 domes and 1 lava flow show a range in temperatures from 748 to 945 C for core compositions, which are taken to represent a pre-mixing temperature of the magma, and 862 to 989 C for rim compositions, which are interpreted to represent a post-mixing temperature. Diffusion profiles in Fe-Ti oxides suggest that mixing preceded eruptions of trachydacites over timescales of ranging from 1 month to 2 years.

46. U-PB DATING OF ZIRCON CRYSTALLIZATION IN THE HOT CREEK RHYOLITE, LONG VALLEY CALDERA, CALIFORNIA: NO CRYSTAL MEMORY OF BISHOP TUFF MAGMA

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The 760 ka eruption of Long Valley caldera produced a 17 × 32 km collapse depression and ejected more than 600 km^3 of rhyolite magma that is preserved as the regionally extensive Bishop Tuff. Since collapse, more than 100 km^3 of rhyolite lava has erupted onto the caldera floor. The origin and significance of these rhyolites are unclear: At the extremes, they represent tapping of residual Bishop magma or represent new rhyolite that is essentially unrelated to the caldera-forming magma. In order to determine whether post-caldera rhyolites at Long Valley retain a "memory" of crystallization in the Bishop magma chamber, we dated zircons from the Hot Creek rhyolite lava flow, which erupted at 329±3 ka (sanidine Ar/Ar age; Heumann, 1999). High-resolution ion microprobe ^{238}U-^{206}Pb dating of single Hot Creek zircons (n=11) yields a common Pb- and ^{230}Th-corrected weighted mean age of 311±22 ka (1□, MSWD=1.4). The results indicate that rhyolites erupted around ~330 ka do not contain a crystal "memory" of Bishop magma, which in turn suggests the generation and differentiation of new post-collapse rhyolite, or that residual Bishop magma was re-heated to superliquidus conditions. The close overlap between crystallization and eruption ages suggests that the Hot Creek rhyolite was only briefly stored before eruption. In contrast, ^{238}U-^{230}Th dating of zircons and major minerals from a ~0.6 ka post-collapse rhyolite suggests storage on the order of 10^5 years prior to eruption (Reid et al., 1997).

47. NEOGENE ALKALINE/SUBALKALINE VOLCANISM IN THE EASTERN MOJAVE PROVINCE

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Neogene volcanism in the eastern Mojave Desert has resulted in the emplacement of a suite of related subalkaline to alkaline rocks. The earliest event began at approximately 13.0 Ma and resulted in the emplacement of hypabyssal sills of rhyolitic to trachydacitic composition at Mesquite Pass. This was followed one to two million years later by flows of trachyandesite (pyroxene andesite), 15 km to the west in the Halloran Hills. Following a hiatus of three to five million years, renewed volcanic activity in the southern Halloran Hills and Cima volcanic field resulted in trachybasalts (hawaiites) and basaltic trachyandesites (mugearites). This phase of volcanism continues to the Present. Our study analyzed over 130 rock samples for 21 major, minor and trace elements. The data define a trend of high K_2O+Na_2O volcanic rocks showing minimal decease in alkalis with decreasing silica content over time. Trace element analyses of the andesites and basalts indicates continental crust played has played an important role in their genesis.

We suggest that Neogene volcanism began during the initial stages of late Miocene detachment and has continued to Recent time, as upwelling asthenosphere has occupied the void created by the thinning lithosphere. The compositional variation in the related members of the rock suite reflect progressively deeper melting, from shallow crustal rhyolite and trachydacite to lower crustal pyroxene andesite to asthenospheric mantle basalts. Assuming a stationary heat source, Neogene volcanism requires the eastern

Mojave to have undergone clockwise rotation at an average rate of 5 mm/year. This rotation appears to consist of two distinct events; a period of nearly east-west motion from 10 to 13 Ma, related to detachment, and a younger north-south directed event from the Present to 7 Ma, a consequence of dextral shear.

48. VOLCANIC PETROLOGY, GEOCHEMISTRY AND STRATIGRAPHY OF THE GRANDE SOUFRIERE HILLS VOLCANO, DOMINICA, WEST INDIES

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Dominica, located in the center of the Lesser Antilles island arc, has eight potentially active volcanoes. The Grande Soufriere Hills volcanic center, one of the least-studied centers on the island, has not experienced an eruption for approximately 10,000 years. Stratigraphic studies suggest that this center is dominated by eruptions of matrix-supported *block and ash flow* and *surge deposits* generated by dome collapse (*Pelean-style eruptions*). Volcanic rocks from this center are all *porphyritic andesites* characteristic of *subduction zone magmas*. Plagioclase crystals many displaying oscillatory zoning or inclusion-rich cores are the dominant *phenocrysts*. *Mafic phenocrysts* include hornblende, which varies from unaltered to strongly oxidized and pseudomorphed, together with lesser amounts of hypersthene, augite and magnetite. The andesites erupted by the Grande Soufriere Hills range from 58–63 wt% SiO_2 and show decreasing trends of Al_2O_3, FeO, MgO, CaO, TiO_2, Sr, V, and Sc and increasing trends of Na_2O, K_2O, Ba, Rb, and Zr with increasing silica. These geochemical variations can be explained by *fractionation* of *phenocryst* phases from a parent magma of *basaltic* composition.

49. PALEOMAGNETIC EVIDENCE FOR TIMESCALES OF MULTI-VENT BASALTIC ERUPTIONS IN BIG PINE VOLCANIC FIELD, CALIFORNIA

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Previous research indicates that basaltic volcanic fields are monogenetic; that is, they undergo a single eruption that lasts no more than about ten years. Alternatively, some workers have suggested that certain basaltic volcanic fields are polygenetic, in that they erupt multiple times over hundreds to thousands of years. Identifying volcanic areas as either polygenetic or monogenetic is important for hazard analysis since polygenetic volcanoes, being longer-lived, may pose a greater hazard to humans and to the environment than monogenetic volcanoes. A combination of reconnaissance mapping and paleomagnetic analysis are used to determine whether Big Pine Volcanic Field (BPVF), Owens Valley, California is monogenetic (short-lived) or polygenetic (long-lived). The BPVF is composed of 22 cinder cones and their associated lava flows. One hundred and five oriented samples were collected for paleomagnetic analysis from flows spanning 8 kilometers across the BPVF. Step-wise AF demagnetization procedures showed that all samples record normal polarity, consistent with K-Ar dates for the Taboose Creek volcanic center of 130 ka. Past studies of the BPVF imply that some flow units may be as old as 1 Ma (Connor and Conway, 2000); however, samples of that age should record reversed polarity. Characteristic remanent directions were calculated using principal component analysis for each sample. Site-mean directions from 21 sites cluster tightly, suggesting that sampled flows were erupted over a very short (<1000 years; monogenetic) time period and did not record significant changes in the earth's magnetic field. VGP calculations for site mean directions will help confirm this interpretation.

50. CONSTRAINING THE RATE AND STYLE OF MAGMA ASCENT AT MAMMOTH MOUNTAIN, EASTERN CALIFORNIA

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Constraining the timescales and styles of magma ascent was performed by investigating the thickness, mineralogy, and texture of amphibole and biotite reaction rims found in Mammoth Mountain domes and lava flows through Scanning Electron Microscopy (SEM). Hornblende phenocrysts are typically angular, and surrounded by reaction rims composed of plagioclase, pyroxene and Fe-Ti oxides. Though all samples are similar in mineralogy, rim microlites range in size from 2 to 23 um and rim thicknesses range from 3–275 um in diameter, indicating highly variable eruption pathways for magmas erupted over Mammoth's history. Rim textures of samples taken from Dragon's Back, located on the southwestern periphery of the dome complex, are texturally zoned, where the rim adjacent to groundmass is coarser relative to rim microlites adjacent to the phenocryst. This indicates that the Dragon's Back magma body likely stalled in the shallow crust at depths of ~5 km and ~1 km during its ascent to the surface prior to eruption. Rim textures of samples taken from elsewhere on the Mammoth edifice are homogenous with respect to rim microlite grain size. Aspect ratios of the reaction rim microlites from all samples range from 0.9 to 5.9 with a maximum crystal length of 12.7 um, suggesting that ascending magmas do not rise to the surface at a constant rate, but rather have a tendency to stall en route at shallow depth (~1 km) for 5–10 days prior to extrusion.

51. BASALTIC VOLCANISM AND VOLCANIC HAZARDS AT BIG PINE VOLCANIC FIELD, INYO COUNTY, CALIFORNIA

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The Quaternary Big Pine Volcanic Field (BPVF) located in the Owens Valley eastern California; is a considerable volcanic hazard. BPVF contains approximately 28 individual vents forming N-S trending lineaments on both sides of the Owens Valley. Except for a single rhyolitic dome in the center of the field the primary eruption product is basalt issued from cinder cones and fissure vents. Along the west margin of the valley, cinder cones, spatter and fissure vents are aligned along fault scarps. Vents along the eastern margin of the valley comprise cinder cones and their associated lava flows. Approximately 25 total basaltic lava flows issued from volcanic vents at BPVF, with an average flow length of ~7 kilometers; the longest lava flow is approximately 9 kilometers in length. Our preliminary field mapping establishes that individual vent clusters may be associated with multiple lava flows with distinct mineralogy. At a vent cluster in the western BPVF, pahoehoe lava is restricted to within about 1.5 km of its fissure vent. This pahoehoe flow transitions to aa flow at about 1.5 km from the vent, suggesting a decrease in magmatic discharge rate from the vent during a Hawaiian style eruption and, in turn, a decreasing volumetric flow rate of lava over the course of the eruption. In contrast, a lava sequence from a cinder cone on the eastern portion of BPVF comprises thin (<0.5 m) pahoehoe flows capped by thicker (1–2 m) aa flows, suggesting increasing magmatic discharge over the course of this Strombolian eruption.

52. FIELD RELATIONSHIPS AND MINERAL ABUNDANCES OF THE ~5000 YEAR OLD BASALTS ERUPTED FROM RED CONES VOLCANOES, CALIFORNIA

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Red Cones volcanoes, located ~10 km SW of Mammoth Mountain, in the eastern Sierra Nevada of California, erupted approximately 5,000 years ago. Cinder and lavas range narrowly in crystal content from 5 to 8 vol%, and contains plagioclase, olivine, clinopyroxene, and magnetite with traces of ilmenite. Combining field mapping with a mineral abundance investigation, we developed the following model of eruption at Red Cones. Stage 1 is characterized by the initiation of eruption from the southern cone with effusion of lavas fed by a rising basaltic dike. These lavas underlie both cinder cones and are thickest beneath the south Red Cone. Stage 2 activity includes Strombolian style eruptions at both cones, where eruptions from the southern crater is more energetic and voluminous based on its greater elevation and the presence of a more extensive and coarser-grained basaltic bomb field on the S. Red Cone crater rim. Stage 3 of the eruption is characterized by magma erupting from both cones, resulting in the breaching of both cones on their SW crater walls and the emplacement of thin, sheet-like lavas with well-developed levee walls, and tendency to develop lava lakes (pools). Over time, eruption rate declines at both cones resulting in emplacement of aa lava flows from the south cone and agglutinate spatter flows from the north cone.

53. RHYOLITE MAGMATISM IN THE BIG PINE VOLCANIC FIELD, EASTERN CALIFORNIA

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The Quaternary Big Pine volcanic field (BPVF), Owens Valley, eastern California, is primarily basaltic volcanic field, containing approximately 30 cinder cone volcanoes and associated lava flows, and a single rhyolite coulee erupted at ~ 1 Ma. At nearby Coso volcanic field, an abundance of rhyolite relative to basalt suggests crustal melting by mafic magmas stored in mid to upper crustal reservoirs, whereas the paucity of rhyolite relative to basalt at BPVF suggests only brief crustal residence of ascending mafic magmas (Mordick and Glazner, 2006). In order to determine the origin of rhyolite magmatism at BPVF, we have undertaken a detailed petrologic study of the Fish Spring rhyolite, located in west-central portion of BPVF. Fish Springs coulee is approximately 1.8 × 0.8 km in area, and represents effusion of at least 0.7 km^3 of magma. Discontinuous tuff deposits occur on the southern portion of the coulee, which may represent an early explosive phase of the eruption. The outer portions of the coulee are composed of autobrecciated and felsitic rhyolite, and internal portions exposed by quarrying are flow banded and pumiceous. The Fish Springs rhyolite is crystal poor (~1%) and perlitic, containing small (<0.5 mm) phenocrysts of plagioclase, quartz, orthopyroxene, clinopyroxene, biotite, hornblende, and zircon, as well as apparent xenoliths of basalt. The crystal-poor nature may reflect near-liquidus temperatures or filter pressing of a crystal-rich source. The ultimate mechanism for rhyolite generation at BPVF may be crustal melting or extreme fractional crystallization of mantle-derived magma.

54. CENOZOIC VOLCANISM ON THE DARWIN PLATEAU

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The Darwin Plateau lies near the southern end of the Inyo Mountains, the Panamint Valley to the east and the Owens Valley to the west. A series of basaltic flows were emplaced on the plateau from 8 Ma to 4 Ma. Basalts of the Coso field (2 Ma-Pres.) lie 50 km to the southwest and the Ricardo volcanics (10–8 Ma) 100 km to the south-southwest. Sixty basalt samples from the Darwin Plateau were collected and analyzed for major, minor and trace elements. Those analyses were compared to others for the Coso and Ricardo volcanics.

The Darwin basalts show considerable variation in composition. The majority are olivine tholeiites, in marked contrast to the quartz-normative tholeiites of the Ricardo volcanics and the nepheline normative alkali basalts of the Coso field. Petrographic examination reveals that Darwin basalts often contain altered olivine phenocrysts with reaction rims of iddingsite. Basalts from the Ricardo field have only pseudomorphs after olivine while phenocrysts of unaltered olivine are common in the Coso volcanics. The Darwin field is also unusual in that flows of both alkaline and subalkaline composition have been documented, suggesting changes in either depth of melting or oxygen fugacity.

The compositional variation for Owens Valley basalts may reflect the changing tectonics of the valley. Early *Q* normative tholeiites (Ricardo - 10 Ma) were emplaced during range-front normal faulting while the younger basalts of the Coso field (<2 Ma) are related to dextral shear. The Darwin basalts (8–4 Ma) represent a transitional phase with subalkaline flows perhaps related to normal faulting and alkaline flows related to right-slip.

55. PHYSICAL AND CHEMICAL CHARACTERISTICS OF VOLCANIC HOTSPRINGS AT WOTTEN WAVEN, DOMINICA, LESSER ANTILLES

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The island of Dominica located at the center of the Lesser Antilles volcanic island arc contains 8 potentially active volcanoes giving it one of the highest concentrations of active volcanoes in the world. Evidence for volcanic activity, since European arrival on Dominica in the 17th century include two phreatic eruptions and 17 volcano-seismic crises. In addition the island has over 30 volcanic-related hot

springs. In 2003 a sampling program of these hot springs was initiated with the most recent data collected in July 2006 to provide a baseline for volcanic monitoring. This presentation will provide a detailed study of the temperature, pH, chemistry and geothermometry of 15 hot springs located within the Wotten Waven caldera that last erupted around 1000 years ago. Initial results show that the Wotten Waven springs exhibit temperatures of between 48° and 102°C, and have an average pH of 3.5. Over the period of the study many of the springs have shown small but measurable increases in temperature and significant changes in water chemistry, e.g. increases in U and Th and decreases in transition metals. Silica geothermometry on spring water give fluid source temperatures of between 58° and 109°C. Preliminary conclusions suggest considerable water-rock exchange with seawater playing a significant role in the hydrothermal system.

56. ERUPTIVE HISTORY OF SOUFRIERE VOLCANO, ST. VINCENT AS ILLUSTRATED BY THREE PYROCLASTIC SEQUENCES

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Studies on three *pyroclastic* sequences from Soufriere Volcano, St. Vincent have revealed significant differences in eruptive style over time. 1) During the Late Pleistocene, *Plinian*, *Vulcanian* and *Strombolian* eruptions produced deposits, which range in thickness from 50 m in the northeast to 2 m in the south and cover about 55% of the island; 2) Stratigraphic studies of the 1902 eruption indicate an initial sequence of surges and flows overlying a well-developed paleosol, followed by many thin fall beds. Both fall and flow deposits are composed of a combination of *juvenile clasts*, *lithic fragments*, crystals, and *accretionary lapilli*. Although the abundance of *accretionary lapilli* in most deposits indicates a significant hydrologic component throughout the eruption, the variations in their amounts between the different beds suggest that the water-magma contact fluctuated significantly during the eruption; 3) Deposits from the he 1979 eruption are dominantly fall deposits with abundant *accretionary lapilli*, and minor flow deposits. The former can be subdivided into a lower blue-grey (explosive events of April 13 and 14) and an upper yellowish brown unit (explosive events April 17–26), and generally show a bimodal grain-size distribution with the secondary coarse mode produced by the abundant *accretionary lapilli*. The presence of *accretionary lapilli* together with the fine-grained nature of the deposits all suggest that the eruptions were *phreatomagmatic* in origin. The apparent absence of *juvenile fragments* in the lower *pyroclastic flow* suggests that the initial eruptions represented the explosive shattering of the 1971 dome.

57. IMMIGRATION IN THE OCEAN: STATOLITHS AS LARVAL PASSPORTS

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To test hypotheses about larval dispersal and how it impacts population dynamics, an effective means of identifying the sources of recruits to populations must be developed. Trace elements in calcified structures like statoliths have the potential to naturally tag marine larvae with a characteristic chemical composition at their birthplace and could be used to determine sources of recruits. However, this tool requires that there be consistent differences of trace elements in statoliths among populations at spatial scales relevant to larval dispersal. To estimate the spatial and temporal variability of trace elements in larval statoliths throughout Kellet's Whelk's (*Kelletia kelletii*) range we collected egg-masses at 22 sites from Monterey, California, USA to Isla San Roque, Baja California, Mexico during the summers of 2004 and 2005. Here we present evidence that trace elements (Mg, Sr, Ba, Ce and Pb) in larval statoliths of *K. kelletii* vary on a regional scale (MANOVA, $p < 0.0001$) and the differences among regions are consistent between years. Linear discriminant-function analysis (DFA) correctly classified 40% of statoliths to their natal site ($n=22$) and 70% of statoliths to their natal region ($n=3$). The results suggest that statoliths can be used to assign recruits to their source on a regional scale. Thus, statoliths could be used as to test hypotheses about exchange of larvae across the well-known biogeographic boundary, Pt. Conception, CA and between the California, USA and Baja California, Mexico.

58. GLOBAL POPULATION STRUCTURE OF THE TOPE (*GALEORHINUS GALEUS*), AS INFERRED BY MITOCHONDRIAL CONTROL REGION SEQUENCE DATA

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The tope, *Galeorhinus galeus*, is a medium sized member of the order Carcharhiniformes (Triakidae), currently distributed globally in temperate waters. Global populations of *G. galeus* are considered to be in decline due to the exploitation of shark fisheries over the past 100 years. Little is known of the northeastern Pacific population of *G. galeus*, and recent observations off the California coast indicate an increase in numbers. To determine the genetic structure of northeastern Pacific *G. galeus* populations, and the levels of gene flow among globally distributed populations, samples (n = 96) were collected and analyzed from five geographically dispersed populations (Argentina, Australia, California, South America, and the U.K.). A 1006-bp section of the 1068-bp mitochondrial control region revealed 33 polymorphic sites with 20 transitions, 11 transversions, and 2 deletions producing 28 haplotypes. Haplotypes were unique to their geographic location with only one haplotype shared between Africa and Australia. Overall, populations demonstrated high levels of haplotype diversity (0.9004 +/− 0.0172), and low levels of nucleotide diversity (0.0065520 +/− 0.003458). Estimated migration rates were low (M = 0.05–0.97), resulting in significant genetic structure (F_{ST} = 0.27151 and Φ_{ST} =0.85642; $P < 0.001$) among populations. Due to an apparent lack of migration across ocean basins, populations of *G. galeus* appear to be isolated from each other with little to no gene flow occurring among populations. As a consequence of this isolation, increasing numbers of *G. galeus* in the northeastern Pacific can be best explained by local recruitment and not input from foreign populations.

59. REPRODUCTIVE LONGEVITY IN THE POLYCHAETOUS ANNELID *DINOPHILUS GYROCILIATUS*

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The polychaetous annelid *Dinophilus gyrociliatus* is a minute worm measuring from 0.5 to 1.5 mm in length and reaches sexual maturity in 7–10 days. Polychaetes reproduce in a variety of ways, but this species is unique in its method. The hermaphroditic worm lays two sizes of eggs in a capsule. The larger eggs, numbering from 1 to 12, become females, and the smaller eggs, numbering 1–3, become males. While still in the capsule, the male pierces the female to transfer its sperm which initiates the development of gonads. The male then dies. The female, now a hermaphrodite, escapes from the capsule and begins feeding. Worms were fed a suspension of commercial fish flakes. The objective of this research was to determine the reproductive longevity of this species. Twenty worms were used in this experiment. Eggs were laid in capsules five days after emergence and every two to five days thereafter for up to eleven times. Beginning with the third egg laying, both male and female eggs were also deposited without a protective capsule. These eggs did not develop. It was theorized that developmental failure was the result of inadequate food, inability of forming capsules, or insufficient sperm.

60. THE MECHANISM OF MALE CHOICE IN THE SEMELPAROUS POLYCHAETE *NEANTHES ACUMINATA*

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Neanthes acuminata [*N. arenaceodentata* and *N. caudata*] is a semelparous polychaete found in brackish and marine waters. Individuals construct mucous-lined burrows in shallow sandy sediments. Male and female individuals form monogamous pairs and occupy the same burrow to reproduce. The female then dies 2–3 days after shedding her eggs. The male fertilizes the eggs and undertakes sole parental care, using undulating body movements to oxygenate the eggs. The juveniles leave the tube at 21 days and begin to feed. After this time, the male is ready to reproduce again. Although there has been extensive research into the aggression and behavior of this species, this study focused on mate choice in relation to dominance and

previous reproductive encounters. Dominant males were found to be favored over subordinate males; experienced males, those that have successfully produced a brood, were found to be preferred over inexperienced males. Furthermore, experienced males were preferred over all other variables. Further experiments were carried out to determine if the "scent of experience" had a chemical basis. It was found using conditioned water that males who previously failed to attract a female could be made into winners by placing the loser into water conditioned by an egg-caring male. This work has posed further questions regarding the chemical signalling involved in aquatic environments and has opened up research opportunities into the rare occurrence of mate choice in a marine invertebrate.

61. TO SETTLE OR NOT TO SETTLE: SEASONAL SETTLEMENT OF OYSTER LARVAE, *OSTREA CONCHAPHILA*, IN TWO SOUTHERN CALIFORNIA ESTUARIES

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Declines in populations of the native west coast oyster, *Ostrea conchaphila*, Carpenter, 1857, have piqued recent interest in restoring its populations. Since local population persistence is influenced by larval settlement, information about the magnitude and timing of settlement will provide valuable contributions to restoration efforts. Previous literature based on an anomalous open coast population in La Jolla, CA found that settlement of *O. conchaphila* occurred once seawater reached 16°C and ceased once temperatures fell below that point. To observe variation larval settlement over seasons within the more common estuarine habitat in southern California, we placed ceramic tiles in two locations within Upper Newport Bay, Newport, CA and in two locations within Aqua Hedionda Lagoon, Carlsbad, CA. Temperature was monitored continually at each site throughout the duration of the experiment. Tiles were collected and oyster settlers counted during spring tides to pinpoint peaks in settlement. There was significant seasonal variation in settlement, with the significantly greater settlement occurring during June 2005 and June 2006 within both estuaries. Contrary to previous findings, we did not observe a universal temperature trigger predicting the initiation and termination of oyster settlement, nor any significant correlations linking water temperature, salinity, or tidal height with peaks in settlement.

62. MEDIAL RED MUSCLE DEVELOPMENT IN THE YELLOWFIN TUNA (*THUNNUS ALBACARES*)

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Fishes use myoglobin-rich, slow-twitch, oxidative (red) muscle to power sustained swimming. Although adult tunas can elevate red muscle temperature above ambient water temperature by using counter-current heat exchangers to conserve metabolic heat generated by the red muscle, larval and early juvenile tunas have not developed enough red muscle to maintain elevated temperatures. Elevated red muscle temperatures may be necessary before tunas can expand their range into cooler waters. The purpose of this study was to determine when and how red muscle forms by describing red muscle development in a size series of juvenile yellowfin tuna, *Thunnus albacares*. Fish were raised to sizes of 40.08–74.03 mm fork length (FL) at the Inter-American Tropical Tuna Commission laboratory at Achotines Bay, Republic of Panama. Larger yellowfin juveniles (up to 188 mm FL) were collected by hook and line near fish aggregating devices off Oahu, Hawaii. Samples were frozen in liquid nitrogen, sectioned at 60% of fork length, and stained for succinic dehydrogenase, which differentially stains for the higher mitochondrial density in red muscle fibers. The Scion Image analysis program was used to calculate the amount of red muscle from digital images of each cross-section. The cross-sectional area of red muscle increases with size faster than the total cross-sectional area increases; therefore, %RM increases with FL. As juvenile yellowfin grow, red muscle develops gradually, producing an increasing amount of red muscle to power sustained swimming and to generate heat for endothermy, thereby potentially affecting recruitment and thermal range expansion.

63. AN EMBRYONIC STAGING SERIES FOR THE CALIFORNIA GRUNION, *LEURESTHES TENUIS*

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The California grunion *Leuresthes tenuis* is a beach-spawning marine fish with embryos that develop in a terrestrial environment and do not hatch until environmentally triggered. Spawning and hatching both are linked with tidal height during syzygy tides. Grunion are competent to hatch in 10 days but can delay up to three weeks longer if the oviposition height on shore is not reached by the following syzygy tides. Development must be timed to conserve yolk in case of a delay, while preparing the embryo for instantaneous hatching whenever the tide rises. This study provides the first detailed description of the early embryology of the California grunion. Unfertilized eggs were collected during a spawning run, artificially inseminated, and incubated at 20 ± 1°C in the laboratory. Embryos were observed by light microscopy for delineation into stages. Diagnostic features in the earliest stages include number and relative size of blastomeres, shape of the blastoderm, extent of epiboly, development of optic and otic vesicles, and number of somites. Later, heart development, blood circulation, body movement, tail and fin development, and changes in organs such as the swim bladder, spleen, and gallbladder were examined. Stages are named rather than numbered to allow for expansion and flexibility in the staging series as more is learned about grunion life history. Although grunion development has characteristics in common with the established staging series of two aquatic teleost fishes, the zebrafish and medaka, grunion have unique features related to their terrestrial incubation and dependence on the tidal cycle.

64. MICROSATELLITE AND MORPHOLOGICAL INVESTIGATION OF AN APPARENTLY DISJUNCT NORTHERN POPULATION OF CALIFORNIA GRUNION, *LEURESTHES TENUIS*

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California grunion *Leuresthes tenuis* are marine fish endemic to outer coastal waters of California and Baja California, Mexico. Grunion spawn on sandy beaches completely out of water, every two weeks following the highest tides of the month, from early spring through August. Their traditional range and primary spawning habitat is southern California. Since 2001, small numbers of grunion have been reported from trawl samples in San Francisco Bay, and in 2005, grunion spawning was verified on a sandy beach in the Bay. For our study, grunion were sampled from three locations: Doheny State Beach in Dana Point, Orange County; Malibu Lagoon (Surfrider) State Beach in Malibu, Los Angeles County; and Robert W. Crown Memorial State Beach in Alameda County on the east side of San Francisco Bay. Grunion collected during spawning runs were assessed using morphological measurements and microsatellite primers isolated from *Odontesthes argentinensis* and *O. perugiae*, also from the family Atherinopsidae, the New World silversides. Grunion from San Francisco Bay were significantly smaller in length and mass and also proportionally distinct as well from grunion collected in the two southern locations, but grunion from the two southern locations did not differ from each other. However, our genetic data showed no difference between any of the three populations of grunion. Interpretations of these data include possible recent colonization of San Francisco Bay with heavy selection for adaptive traits in advance of divergence in the neutral genetic markers, or panmixia between grunion populations throughout their range, with high phenotypic plasticity.

65. RECIPE: A NOVEL RESEARCH PROJECT THAT IS MORE THAN HALF-BAKED

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Having completed the acquisition of 1500 acres of coastal sage scrub contained within the greater Los Angeles metropolitan region, the Palos Verdes Peninsula Land Conservancy found itself in a position to promote a standard of excellence for restoring and sustaining native habitat, and for documenting ongoing changes as the habitat improves. Management at the Land Conservancy knew that scientific research was essential for providing feedback to the restoration staff, but also recognized that greater good could be realized through a broad-based community effort. This forward-thinking approach led to the creation of the Research, Education, and Community Involvement Program for the Environment (RECIPE), which is designed to coordinate scientific research and management information for communication to the restoration community and public at large. Supported by Alcoa Foundation, RECIPE is intended to reach

students from elementary through university level work to foster sound scientific education for youth as well as research opportunities for academia. Barely a year old, RECIPE has been well received throughout the community and has a variety of research projects underway. Initial results have shown that the merger of academia with young students and the restoration staff can be an effective process for discovering how to better restore and manage the open space on the Palos Verdes Peninsula. We utilize multiple avenues, such as newsletters, interpretive flyers, and conferences (such as the Southern California Academy of Sciences' Annual Meeting) as well as peer-reviewed journal articles, to communicate the research results to our local community, the restoration community, and academia.

66. EFFECTS OF A PURPOSE-BUILT UNDERPASS ON WILDLIFE ACTIVITY AND TRAFFIC-RELATED MORTALITY IN SOUTHERN CALIFORNIA: THE HARBOR BOULEVARD WILDLIFE UNDERPASS

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Conservationists have advocated the construction of wildlife crossing structures for the purpose of reducing traffic mortality of wildlife and maintaining habitat connectivity in increasingly fragmented landscapes. In May 2006, construction was completed on a wildlife underpass beneath Harbor Boulevard, a four-lane road that bisects the Puente Hills, one of the few remaining large tracts of coastal sage scrub habitat in southern Los Angeles County. We used road-kill surveys, track-stations and remote cameras to monitor the frequency of road-killed wildlife and the activity of medium and large mammals in the vicinity of the underpass before, during and after underpass construction. Our aim was to determine whether such underpasses reduce traffic-related mortality of wildlife and improve connectivity of natural habitats. As of April 2007, coyotes and deer were photographed at the underpass an average of 26.6 and 2.0 times per month, respectively. Track-station activity, and the diversity of species represented, was especially high in the center of the study area, suggesting that wildlife activity is greater farther from more intensely urbanized areas. Incidence of road-kills was very high on Harbor Boulevard relative to the rest of the study area prior to construction; however, as of April 2007, there has been no reduction in the frequency of road-kills on Harbor Boulevard. Although use of the underpass has been relatively high, the lack of any decrease in the number of road-killed animals, suggests that other measures such as fencing might be considered to funnel more animals into the underpass.

67. ETHNOBOTANY IN THE CANADIAN ARCTIC: A SURVEY OF THE COPPER INUIT

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Ethnobotany is the study of how plants are used by people for medicine, food, and material objects. Ethnobotanical research has seldom been conducted in Arctic environments. The Inuit are an indigenous people that currently inhabit Arctic environments in regions north of the tree-line. Inuit territory stretches from Siberia in the west to Greenland in the east. The Copper Inuit are a sub-population of Canadian Inuit who occupy the Kitikmeot Region of the Territory of Nunavut, Canada. Formerly nomadic hunter-gatherers, the Copper Inuit have lived on permanent settlements since the middle of the twentieth century. Despite a departure from nomadism, the Copper Inuit have maintained the practice of subsistence hunting and gathering. This dependency on the environment makes the culture an interesting subject for ethnobotanical research. The objective of this study was to document the use of plants in the traditional medicine, diet, and material culture of the Copper Inuit. An ethnobotanical survey of the plants used by the Copper Inuit was conducted in the Hamlet of Kugluktuk, Nunavut (North 67°47.881′; West 115°13.845′). Data was gathered through unstructured interviews, participant observation, and voucher specimen collection. Uses were documented for 20 plant species contained in 15 families. Thirteen species were used for medicine, seven species were eaten, and a further seven were used as cultural items. These findings are discussed in the context of the traditional and contemporary culture of the Copper Inuit. Further efforts to document traditional Inuit knowledge are indicated by rapid changes in Arctic culture and climate.

68. MALE CRICKET AGGRESSION AND PREDATION RISK: MALE CRICKETS FIGHTING OVER SPIDER SILK

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Male crickets engage in aggression to defend or obtain resources. However, aggression may cause males to be conspicuous and vulnerable to predators. Male crickets may reduce aggression to limit predation risk. I tested the hypothesis that perceived predation risk will influence male aggression in house crickets, *Acheta domesticus*. Paired males were observed under varied degrees of perceived risk and potential benefit. Perceived risk was manipulated by adding spider silk and feces from Western Black Widows and funnel-weaving spiders. Perceived benefits were manipulated by adding cues from three virgin, female crickets. Controls consisted of no cues from female crickets or spiders. Residents showed significantly more aggression and won more contests when presented female cues than no cues, but residents showed no difference in response to funnel-weaver silk. However, male crickets showed significantly more aggression and won more in the presence of black widow silk than any other treatment. All spiders were fed a diet of crickets prior to trials. Additional observations were made using silk from black widows fed mealworms to test if silk cues may be diet based. Crickets showed significantly less aggression and won fewer contests in this treatment than cricket-diet-black widow silk. Results suggest that crickets do not use these spider cues for predation warnings. It appears that black widows may embed cues from their prey into the silk and/or feces. This result suggests a novel diet-based mechanism by which certain web-building spiders might increase the attractiveness of their webs and have higher prey capture.

69. A COMPARISON OF PREDATORY AND NON-PREDATORY MAMMAL MANAGEMENT POLICIES IN THE ELEVEN WESTERN STATES

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This thesis examines the management policies of predatory mammals as they compare to the management policies of non-predatory mammals in the eleven Western States. Policies were measured for bias by determining the minimum number of discrete actions required for the legal take of each mammal under study; these discrete actions are defined as layers of protection (LOP). The results yield qualitative numeric values indicating consistent bias against predatory mammals. This study includes discussions of trophic influences imparted by large mammalian predators on ecosystems, historic origins of anti-predator bias, emerging multi-disciplinary predator management policies, and suggestions for future policies based on appropriate environmental concerns from an ethical perspective. Results of this study indicate both ethical and unethical biases within existing state wildlife management policies. I offer suggestions for creating predator management policies that are both ethical and take into account the necessary public safety issues that are becoming increasingly relevant due to a rapidly expanding urban-wild interface

70. MOTH DIVERSITY ALONG AN ELEVATIONAL GRADIENT IN SOUTHEAST ARIZONA

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The factors that influence biodiversity are the focus of much research in ecology and conservation biology. Our research focuses on moth communities along an elevational transect in the Santa Catalina Mountains in Arizona. The differences in climate along this elevational gradient are correlated with changes in plant communities which shift from desert scrub at low elevation to mixed conifer forest at high elevations. I predicted that, due to their herbivorous nature, moth communities will change as do the plant communities. In addition, the Rapoport-rescue hypothesis predicts that moth diversity will peak at an intermediate elevation due to overlap of species ranges towards the middle of an environmental gradient. To measure moth diversity, blacklight traps were placed at four sites differing in elevation and plant community. Moths are currently being sorted to morphospecies. To date, 10,115 moths have been sorted from 553 morphospecies from the June sampling period. There are substantial differences in species diversity and community composition at different elevations. The highest diversity appears at middle elevations and appears to be a function of increased overlap with species from high elevations. This is a preliminary report on my results; further analysis includes several analyses of samples from July and August. These data help us to gain a better understanding of the vast diversity of insect communities on these mountains and how abiotic and biotic factors might influence their distributions.

71. DIFFERENTIALLY ALTERING THE ABILITY OF *HAEMOPHILUS INFLUENZAE* TO FORM BIOFILMS BY USING SUBTHERAPEUTIC DOSES OF MULTIPLE ANTIBIOTICS

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When studies began showing the concept of antibiotic resistance, researchers felt that the remedy was to give patients lower dosages of antibiotics, as subtherapeutic dosages lead to the inhibition of initial microbial adherence. However, the flaw in such thinking was that all antibiotics behaved the same way at subtherapeutic doses. Additionally, it was believed the difference between planktonic cells (individual bacterium) and biofilms (many bacteria) was virtually none. Bacteria are actually in biofilms for the duration of their existence. It is only when making the transition from biofilm to biofilm that the bacteria are in a planktonic state. The difference between planktonic cells and biofilms is that the latter are much more resistant to antibiotics than are planktonic cells. In order to treat antibiotic resistance, biofilm formation must be observed.

96-well microtiter plates were used throughout the experiment, as they go beyond Petri-dishes which are only able to test for planktonic cell growth and inhibition. Microtiter plates have the ability to test for biofilm growth and inhibition, as they can be introduced to a Victor 3-V Perkin Elmer, 595 nm, plate reader. As biofilms are the predominant state of bacteria, it was fitting to use a plate reader which tested for biofilm growth of Haemophilus influenzae after crystal violet had been added, followed by water, and finally the addition of ethanol.

The plate reader showed a significant biofilm spike for Benzylpenicillin. In other words, Benzylpenicillin was shown not only to fail at subtherapeutic doses, but also to cause patient health to drastically worsen as biofilm formation increased at such a low dose. This spike is what contributes to antibiotic resistance in patients.

Often times patients do not fully finish taking their antibiotics or are started on a sub-therapeutic dose. In the case of some antibiotics, such as Benzylpenicillin, this method leads to a rendering of a much more harmful bacterium than would have been present had no antibiotic been administered or had an MIC (Minimal Inhibitory Concentration) dose been put into place immediately.

72. IS YOUR BEACH IN HOT WATER? WARMING WATER TEMPERATURES CAUSE ERRONEOUS BACTERIAL EXCEEDANCES USING STANDARD BACTERIAL METHODS

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The summer of 2006 saw unusually high water temperatures throughout Southern California. In July and August of that year, a large embayment popularly used for recreational purposes experienced a surprising number of fecal indicator bacteria exceedances. Upon investigation, no presence of human contamination was found. Parallel studies were then performed involving several known methodologies for analyzing bacterial counts. It was determined that the method being used for bacterial analysis, IDEXX Colilert®-18, reported *E. coli* results significantly higher than those obtained using the more traditional membrane filtration and multiple tube fermentation methodologies. False positives were suspected due to this unusual occurrence and research turned to the *Vibrio* genera of bacteria due to its tendency to bloom in warm waters. In order to check for the presence of these organisms, Colilert®-18 positives were plated directly on media known to select for *Vibrio* species. Growth was present on all plates, and likely species included *Vibrio parahaemolyticus* and *Vibrio alginolyticus*. Additional investigations determined that a slight change in the methodology involving diluting the sample volume analyzed from 1:10 to 1:20 resulted in counts comparable with other methodologies. Findings from this study ultimately led to changes in analysis methodology for the San Diego County Department of Environmental Health AB411 sampling program and others.

73. CONSEQUENCES OF MANY GENERATIONS OF HYBRIDIZATION UNDER BOTH STRESSFUL AND BENIGN CONDITIONS

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Although it is well established that hybrid fitness problems are often delayed until the second generation, little is known about the consequences of hybridization in later generations. Much work has focused on natural hybrid zones where populations have been hybridizing for long time periods, but in order to better understand the process of hybrid speciation, it is necessary to also observe intermediate hybrid generations. The intertidal copepod, *Tigriopus californicus*, serves as an excellent model for hybridization studies due to its ease of husbandry and the ability to set up controlled crosses for genetic manipulation. Its short generation time (~23 days) and abundance of population-specific markers makes it a particularly tractable system for studying the outcomes of hybridization over multiple generations. This study uses *T. californicus* to assess hybridization in both benign and stressful (high salinity) conditions. Here we report morphometric and fitness data after 18 months of experimental hybridization. In particular we are interested in determining (1) if environmental stress alters the magnitude or duration of outbreeding depression and (2) whether or not hybridization can generate new genetic variants that are favored under environmental stress. This work is directly relevant to current concerns about the impacts of invasive species mixing with native populations, or farmed organisms mixing with wild populations. It also provides an example of the long-term consequences of hybridization under both benign and stressful conditions in a rigorous way that would be difficult to achieve for most species of concern.

74. PERSISTENCE AND ITS LIMITING FACTORS IN SOUTHERN CALIFORNIA KELP BEDS

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Sporadically over the past century and consistently over the last four decades, kelp beds have been monitored frequently enough for it to be well known that kelp beds do not typically persist for long periods of time. Herein we explore the reasons for the lack of persistence in southern California kelp beds by means of kelp bed maps and aerial photography collected from a variety of sources. The persistence of an individual bed is dependent on many variables some of which are naturally occurring environmental perturbations such as nutrient availability as dependent on manifestations of El Niños and La Niñas, storms, sediment deposition, persistent phytoplankton blooms, and anthropogenic influences such as wastewater discharges, erosion, and predator-prey imbalances brought on by overfishing.

By looking at the long-term record dating back to Crandalls original giant kelp maps of 1912, we have a baseline to explore the persistence of the kelp beds of southern California. Although information is sketchy for the first half century of the 1900s, enough is available to document large changes in the giant kelp beds that were probably caused by anthropogenic influences or normal coastal processes. These would include the loss of whole kelp beds such as the Sunset Kelp Bed, Palos Verdes Kelp Bed, the Dago Bank Kelp Bed (Horseshoe Kelp), Doheny Kelp Bed, Santa Margarita Kelp Bed, the Mexican Border Kelp Bed, and the reduction in size of numerous kelp beds along the southern California coast. Interestingly, at least one kelp bed now exists where none was recorded by Crandall in 1912.

The long-term record can also give us insight to better understand the cyclical natural processes which also affect kelp bed persistence. These well known environmental perturbations of the oceanographic regime were added to in 2005 and in 2006. In those two years we saw losses throughout the Southern California Bight that were probably caused by excessive phytoplankton blooms reducing available light. These very normal (almost yearly) occurrences persisted long past typical durations and probably were the responsible agent for large decreases seen in 2005 and in 2006.

The more than 50 distinct beds that occur offshore of Ventura, Los Angeles, Orange, and San Diego Counties have been surveyed during the past century which allows for a temporal view of each of the major kelp beds. From this review, insight is provided of the kelp beds response to and the aftermath of these limits to growth of our kelp beds.

75. A SATELLITE DERIVED DATABASE OF GLOBAL KELP CANOPY DISTRIBUTION

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A global database of kelp canopy distribution was produced from NASA GeoCover images for the years 2000 and 1990. The GeoCover images are a global set of cloud-free LandSat 5 Thematic Mapper (TM) and LandSat 7 Enhanced Thematic Mapper (ETM+) imagery funded by NASA and processed by MDA Federal Inc. The ETM+ imagery has a spatial resolution of 28 m and has three bands in the visible spectrum and one near-infrared band that are useful for kelp mapping. The kelp canopy regions were identified by first masking the land potions of the imagery so that the classification process could focus on the nearshore regions and then conducting a minimum spectral distance unsupervised classification. The accuracy of the classification process was evaluated using a variety of independent data sources in southern California, Baja California, southeast Alaska, central Peru, and northern Chile. The kelp canopy areas along the west coast of North America were identified accurately from the satellite imagery. However, many of the beds of *Macrocystis integrifolia* in Peru and northern Chile were missed in the classification process. This appears to be due to the narrow width of these beds and their position adjacent to the shoreline. This study has shown that LandSat imagery is a cost-effective method for monitoring kelp populations in remote regions, such as the subantarctic islands; where surveys are infrequent, but where global climate change could have significant impacts on kelp distributions. The kelp canopy polygons are available in kml format for viewing in Google Earth.

76. PHOTOACCLIMATION ALONG A VERTICAL GRADIENT IN DIFFERENT GROWTH STAGES IN THE ELK KELP, *PELAGOPHYCUS PORRA*

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The Elk Kelp, *Pelagophycus porra*, is commonly observed in deep (20–30 m) water on the outer edge of Giant Kelp, *Macrocystis pyrifera*, forests in southern California and northern Baja California, but rarely occurs in shallower water or within the giant kelp beds. We used a series of transplant experiments, demographic monitoring, and physiological measurements to investigate *P. porra*'s apparent inability to encroach into the more abundant giant kelp beds along the southern California coast. Our results indicate that transplanted *P. porra*'s juveniles exhibit similar growth and survival across a vertical gradient. Physiological measurements using PAM fluorometry indicate that while this species exhibits characteristics of a species adapted to low light environments, such as deep-water habitats, individuals are able to photoacclimate to increasing light levels as they grow towards the surface. This ability to photoacclimate is variable within the large (up to 20 m long) blades, with portions near the surface behaving like light-adapted species and parts hanging in deeper water behaving like shade-adapted species. These results show that this deep-water species has the capability to function as both a low light and a high light adapted species as it grows through the water column as well as simultaneously within a single blade.

77. COMMUNITY-BASED GIANT KELP RESTORATION AND MONITORING IN ORANGE COUNTY, CALIFORNIA

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Historical data indicate that Orange County kelp densities have decreased significantly over the last 25 years. In 2001 a Community Based Giant Kelp (*Macrocystis pyrifera*) Restoration Project began to restore kelp on reefs in Orange County where it historically grew. The (12) 1500 m^2 restoration sites were established over a period of four years. Before any restoration occurred, the reefs were mapped and species abundance and diversity was assessed. A variety of restoration techniques were used. Annual monitoring continued throughout the restoration process. All work was performed by community volunteers under the direction of a lead biologist. These activities are part of a regional project spanning the Southern California bight

78. RESTORED KELP BEDS OFF OF MALIBU AND PROGRESS OFF PALOS VERDES, WORTH DIVING FOR

T. Ford. Santa Monica Baykeeper Kelp Restoration and Monitoring Project, P.O. Box 10096, Marina Del Rey, CA 90295

Swath transects performed in the fall of 2006 describe the successful development of *Macrocystis pyrifera*, in three separate restoration areas off of Escondido beach, Malibu California. An additional area off of Long Point Palos Verdes is in the earlier stages of restoration. Descriptions of actions taken to restore giant kelp communities within Santa Monica Bay and progress to date off of Long Point Palos Verdes will also be presented.

79. FISH-HABITAT ASSOCIATIONS AND THE ROLE OF DISTURBANCE IN SURFGRASS BEDS

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Many studies have been conducted on seagrass communities in protected bays and estuaries as important nursery grounds for fishes and invertebrates. By contrast, there have been few studies investigating faunal-habitat associations in open coastal environments and only one study that has documented the fishes associated with surfgrass beds in southern California. In this study, I explored recruitment and the abundance of older life stages of fishes in surfgrass (*Phyllospadix torreyi*) beds along the open coast of San Diego County. I recorded fishes in surfgrass beds and quantified seven variables of habitat structure on each bed. As expected, the variables that explained variation in the density of fishes were species-specific. Because surfgrass beds are subject to disturbance and loss of habitat may alter the abundance of fishes, I reduced the area of surfgrass beds by 50% and compared the abundance and structure of fish assemblages with unmanipulated beds. Older juvenile and adult fishes showed no response to loss of surfgrass habitat, while recruits showed stronger and more complex responses. Species richness of recruits was lower on disturbed than unmanipulated beds, and the density of recruits on surfgrass only showed a significant interaction between treatments. The densities of recruits of most species were higher on the undisturbed vs. disturbed side of a bed, except for the rock wrasse which showed an opposite pattern. This is the first study to explore fish-habitat relationships in subtidal surfgrass beds and to assess the subsequent impacts of disturbance.

81. EXTRAPOLATING RESULTS OF SMALL-SCALE FIELD EXPERIMENTS TO ENHANCE POPULATIONS OF A CORAL REEF FISH AT LARGE SPATIAL SCALES

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Although field experiments allow rigorous tests of ecological hypotheses, they are usually limited to small spatial scales. We often want to know if their findings extrapolate to larger scales, especially when applying their results to conservation and management. We show first that that density-dependent mortality of reef fish on small habitat patches scales-up to have similar effects on much larger entire reefs that are the size of small marine reserves and approach the scale at which some reef fisheries operate. This result is in accord with a scaling model which indicates that localized events can be aggregated to describe larger-scale interactions with minimal distortion. Experiments on small habitat patches reveal that predators inflict locally density-dependent mortality. As prey become crowded, they suffer a progressively increasing shortage of structural refuges. A manipulation of refuge abundance on entire reefs suggests that a similar interaction occurs at this much larger scale, and enhancing refuge abundance enhances population size at this large scale. The results so far suggest that careful extrapolation from small-scale experiments identifying species-interactions may be possible, and so should improve our ability to predict the outcomes of alternate management strategies for coral reef fishes.

82. THE RELATIVE EFFECTS OF BIOGEOGRAPHY AND SIZE-SELECTIVE FISHING PRESSURE ON THE POPULATION STRUCTURE AND SEX-CHANGE DYNAMICS OF THE CALIFORNIA SHEEPHEAD, *SEMICOSSYPHUS PULCHER*

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California sheephead present an especially interesting challenge in environmental monitoring because they begin life as females and transform into males as they age, forming a harem mating system based on the few large dominant males in the population (Alonzo, 2004b). Depending on the fishing method (live trap, setnet or hook-and-line), recreational and commercial fisheries tend to specifically target either large males or small immature females (Alonzo, 2004a, Adreani, et al. 2004). In this study, populations of California sheephead were analyzed through SCUBA transect data and specimen collection in order to assess the effects of size-selective fishing pressure on the species. While mean fish density appeared to be a function of biogeography and habitat, mean fish size and sex distribution appeared to vary with other influences such as fishing pressure. Fish were consistently larger at remote sites such as Anacapa and Santa Barbara Island, although marine reserves placed in more heavily fished locations were only effective when they were of ample size and suitable habitat. A preliminary GSI curve confirmed the summer spawning season described in previous papers. However, at many of the Santa Catalina Island sites, transitional fish were observed during the summer months, an unexpected occurrence indicative of a disturbed population. Gonad histology confirmed this phenomenon, although the structure of summer transitional gonads was different from transitional gonads collected over the winter. In addition, populations of California sheephead at mainland populations grew at a faster rate and in a different pattern than those at Santa Catalina Island.

83. ISOLATING THE EFFECTS OF LARVAL SOURCE ON THE POPULATION OF A MARINE INVERTEBRATE

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The design of a large artificial reef combined with data from two nearby natural reference reefs has provided a unique opportunity to assess the relative importance of recruitment and post-settlement mechanism on populations of the sea fan, *Muricea californica*. Three significant recruitment events occurred between 2000 and 2005 on the reefs located in southern Orange and northern San Diego counties. Numbers of adult sea fans were strongly affected by recruitment of young-of-the-year sea fans, whereas post settlement mechanisms associated with location and habitat complexity had little effect. Modeling results indicate the initial numbers of adults also have little effect on long-term population trajectories, whereas recruitment and survival rates of the young recruits have a strong influence. Model results also indicate that small differences in these two rates can result in vastly different long-term population numbers. We discuss the implications of these results on the long-term performance and maintenance of a one of the largest artificial giant kelp (*Macrocystis pyrifera*) reefs yet to be constructed.

84. DEMOGRAPHIC PARAMETERS OF YELLOWFIN CROAKER, *UMBRINA RONCADOR* (PERCIFORMES: SCIAENIDAE) FROM THE SOUTHERN CALIFORNIA BIGHT

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Yellowfin croakers, *Umbrina roncador*, are a common nearshore and surf zone species in the southern California bight. 1209 individuals were aged using otoliths. The maximum age was 15 and the von Bertalanffy parameters for females were significantly different than those of males. Females grew faster and larger. Based upon samples collected between 2003 and 2004, annual and instantaneous mortality estimates were $A = 0.4492$ and $Z = 0.5964$. Males and females were found at all size classes and in 51:49

ratio that was not significantly different from a 50% sex ratio indicating that these fishes were gonochores. Fishes were reproductive in the summer months with gonadosomatic indices (males = 5.65% and females = 5.51%) consistent with group spawning fishes. In two separate monitoring programs, their abundance fluctuated appreciably between from 1993–2004 and was declining significantly by the end of this program. This trend was consistent with declining recruitment during this time period.

85. FISH SPECIES COMPOSITION FROM THE SOFT-BOTTOM OF BAHÍA DE LOS ÁNGELES, BAJA CALIFORNIA, MEXICO (2005–2007)

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We studied the composition of the soft bottom fish community at Bahía de Los Angeles, Baja California, México. Six seasonal samples were made during November 2005, February, April, August, November 2006, and February 2007. During each sampling period, we collected fishes using four replicate otter-trawl (5 and 10 m-depth), beach-seines (<3.5 m-depth), and gill-nets (5,-depth), and using hook-and-line. All the species were identified, the number of individuals was recorded, the biomass and size of all fishes were measured and the seasonal variation in the community was determined. A total of 2638 individuals representing 67 fish species were collected. The number of species collected at each sampling period varied from 19 (November 05) to 30 (April and November 06). The number of fishes collected was greatest during spring (April 06) and summer (August 06) when 51.2% (1,350 fish) of the total number of fishes was collected. The most abundant species was *Paralabrax maculatofasciatus* with 895 individuals (33.3%) collected over the course of the study and 506 individuals (56.5%) collected during the summer season (August 2006). *Sphoeroides annulatus* was the second most abundant species (9.4%), followed by *Urobathis halleri* (9.4%), *Etropus crossotus* (6%), and *Xenistius californiensis* (5.1%). According to cumulative abundance of fish species, 22 species accounted for 90.7% of the fishes collected during this study. A number of 23 "rare" fish species with only one or two individuals collected, accounted 1.2% of the total number of individuals. We discuss here the patterns of seasonal variation in the abundance and the occurrence of the most important fish species, using the Index of Community Importance (ICI).

86. IMPACTS OF HABITAT USE ON CONTAMINANT CONCENTRATIONS IN SEVERAL SPECIES OF FISHES COLLECTED IN THE PALOS VERDES SUPERFUND SITE

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Fish from the Palos Verdes peninsula typically have elevated DDT and PCB concentrations due to contamination in the sediments in this region. Concentrations vary among individuals and species in ways that deviate from conventional wisdom that bigger, higher trophic level species are more contaminated. Movement patterns and habitat use may also impact exposure and accumulation of contaminants, but the importance of these factors may be mediated by the nature of the source of the contamination (local point source vs. non-point source). We examine PCB/DDT (point source) and mercury (non-point source) contaminant concentrations of species within two families (Scianidae, Serranidae), to determine how differences in habitat preferences relate to magnitude and variance in contaminant concentrations. Two Serranide species (*Paralabrax clathratus* and *P. nebulifer*) are upper trophic level species that used reef and soft bottom habitats to differing degrees. Two scianide species (*Genyonemus lineatus*, and *Seriphus politus*) are lower trophic level species, the former forages from the substrate and is typically associated with soft sediments and the latter forages from the water column and is typically higher in the water column. In addition to these species, contaminant concentrations in a surf zone scianide (*Menticirrhus undulates*) and a reef-associated herbivore (*Girella nigricans*). These comparisons confirm that habitat use patterns may play a much bigger role than body size and trophic status in determining DDT/PCB concentrations for the Palos Verdes superfund site, and perhaps other sites where the source of the contamination is localized geographically and contained within specific habitats.

87. BALLONA WETLANDS – BOLD VEGETATION GIS MAPPING PROJECT

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In the summer of 2006, a GIS mapping project was started in the BOLD project area of the Ballona Wetlands. This project was undertaken to provide baseline information on the native and non-native plant cover for this site using GPS data and GIS software to map both. Some issues using older equipment were encountered and these issues have been incorporated in the project notes. Using the software, a map has been produced which indicates that a substantial portion of the site is covered with non-native species, including ice plant (*Carpobrotus edulis*), lollipop trees (*Myoporum laetum*), and invasive grasses. These data will be used in monitoring changes consequent on restoration

For example, in the fall of 2006, the salt water flushing of the system was increased by allowing the tidal flood gates to remain open to a higher tidal level. In late spring of 2007, critical areas of the area have been remapped and changes in the plant distributions noted.

88. THE EFFECT OF DL-HOMOCYSTEINE ON MINERALIZATION IN OSTEOBLAST-LIKE CELL CULTURES

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Recent clinical studies document elevated homocysteine (Hcy) serum levels in osteoporotic patients and homocysteinuria is clinically associated with osteoporotic fractures. It is well known that Hcy, an intermediate sulfur-containing amino acid, elicits specific responses from a variety of cell types. However, the cellular mechanisms leading to its effects on the bone cells responsible for mineralization remain incompletely understood. This study investigates the effects of exogenous Hcy on mineralization in the osteoblast-like cell line, UMR 106-01 BSP (UMR cells). UMR cell cultures, treated with varying concentrations of DL-homocysteine in the presence of 0.1 mM copper sulfate, were incubated at 37°C for 60 hours. The cell cultures were subsequently treated with beta-glycerophosphate (7.0 mM) for 24 hours to stimulate mineralization. Cell cultures were washed, fixed in ethanol and stained with alizarin red. Mineral content were quantified using a microplate reader (SpectraMax 190). Hcy concentrations inversely correlated with mineral deposition in the UMR cell cultures. Therefore, elevated Hcy concentrations are associated with poor mineral deposition in UMR cell cultures *in vitro*. Continued studies will be necessary to further elucidate the role of Hcy in bone mineralization in osteoporotic patients.

89. NEUROTOXINS IN OUR ENVIRONMENT

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BMAA (β-methylamino-L-alanine) is an unusual neurotoxic amino acid found in Guam in the cycad *Cycas micronesica* Hill. Biomagnified cycad neurotoxins are linked with the high incidence rates of ALS/PDC, a neurological disease prevalent among the indigenous Chamorros people of Guam. Two years ago, researchers identified that cyanobacterial root symbionts of the genus *Nostoc* produced BMAA. BOAA (β-oxylamino-L-alanine), found in plants of the genus, *Lathyrus*, is another unusual, neurotoxic amino acid similar in structure to BMAA and known to cause lathyrism, a disorder resulting in lower-limb paralysis linked to excessive consumption of the grass pea *Lathyrus sativus* in India, Bangladesh, and Ethiopia. Since *L. sativus* is a leguminous plant species that lives in symbiosis with nitrogen-fixing rhizobia, we hypothesized that the rhizobium itself could be responsible for the production of BOAA in *Lathyrus* and potentially other legumes. We also hypothesized that BMAA could be another possible product of rhizobium bacteria. We tested commercially produced rhizobium used as an inoculant to promote healthy leguminous plants for both BOAA and BMAA. We also tested green beans (*Phaseolus vulgaris*) and snap peas (*Pisum sativum*) from local Farmer's Markets for BOAA and BMAA. All analyses were completed with HPLC analytical techniques. Low concentrations of BOAA were found in *P. vulgaris*

and *P. sativum*, and both BMAA and BOAA were found in rhizobium inoculants. Further investigations using mass spectrometry analysis are now necessary to confirm amino acid identifications.

90. EVIDENCE FOR RAPID LAKE LEVEL CHANGE DURING THE LAST GLACIAL MAXIMUM IN SOUTHERN CALIFORNIA (LAKE ELSINORE)

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A sediment core from the littoral zone of Lake Elsinore, southern California's largest natural lake, provides insight to the climate of southern California from ~22,000–17,000 calendar years BP. Sedimentological data including lithologic description, mass magnetic susceptibility, LOI 550°C, and LOI 950°C indicate rapid changes in the depositional environment at the core site. We interpret these changes as representing variations in lake level and its associated type of sedimentation. For example, we interpret sand as similar to the modern "beach" environment (i.e., low lake level). Conversely, clays represent a deep lake environment (i.e., high lake level). Based on our multi-proxy methodology, we infer an interval of low lake level ca. 22,000 cy BP. From 22,000 cy BP to ~20,300 cy BP, lake level was highly variable reaching a brief high stand centered on 20,070 cy BP and ending by 19,700 cy BP. This high stand is followed immediately by an abrupt regression as evidenced by sand-rich sediment. The timing of this abrupt regression at Lake Elsinore is correlative to the onset of a pronounced lowstand at Owens Lake at ca. 19,700 cy BP (Bacon et al., 2006). By 19,500 cy BP, lake level begins to rise, peaking by 17,900 cy BP. After 17,900 cy BP, there is an inferred gradual lake level regression reaching a sustained low lake level – but higher than the coring site – by 17,120 cy BP. This transgression-regression cycle is observed at Owens Lake by Bacon et al. (2006). These results indicate that the Last Glacial Maximum climate of Southern California was highly variable and regionally congruent.

91. BURST SWIMMING PERFORMANCE AND METABOLIC ENZYME ACTIVITIES IN LARVAL AND JUVENILE WHITE SEABASS (*ATRACTOSCION NOBILIS*)

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The white seabass (*Atractoscion nobilis*) is a large sciaenid fish important to commercial and sport fishing that ranges from Alaska to southern Baja California. Burst swimming is involved in predator escape and is believed to play a key role in fish survival. The purpose of this study was to quantify how burst swimming performance and glycolytic enzyme activities change in developing larval and early juvenile white seabass. Fish were obtained from the Hubbs-Sea World Research Institute Ocean Resources Enhancement Hatchery Program and were reared in the laboratory at 20°C. Fish maximal speed during burst swimming (Umax) was measured in individual fish, ages 1 to 31 days post-hatch, by analyzing video captured at 120 Hz. The activity of the enzymes creatine phosphokinase (CPK) and lactate dehydrogenase (LDH), which produce ATP in glycolytic muscle to power burst swimming, were measured in the same individuals. It was hypothesized that Umax would increase with fish size and that CPK and LDH activities would positively correlate with Umax. We found that both Umax and CPK activity increased with total length, but there was no relationship between LDH activity and total length. Once size affects were accounted for, neither CPK nor LDH activities correlated with Umax. Thus, CPK and LDH activities are not indicators of burst swimming performance in individual larval and early juvenile white seabass. The increase in Umax with total length should lead to an increase in the ability to escape predation and thus an increase in fish survival.

92. SONG RECOGNITION IN PLAYBACK EXPERIMENTS IN ANNA'S HUMMINGBIRD, *CALYPTE ANNA*

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Catchpole (1982) developed a basic model of song function based on songbirds: simple songs are for territory defense and complex songs are for mate attraction. Hummingbirds are not songbirds, and hummingbird species vary in the complexity of their song. Our lab is studying the function of song in hummingbird sister species with similar habitats and behaviors, but very different songs: Anna's hummingbird (*Calypte anna*), which has a complex, learned song, and Costa's hummingbird (*Calypte costae*), which has a simple song that is believed to be innate. I conducted neighbor- stranger song playbacks to determine if male Anna's hummingbirds can distinguish between individuals' songs and if the songs are used in territorial defense. Each bird was exposed to four trials, in random order: a neighboring Anna's song, a stranger Anna's song, a Costa's song and a house finch song. I measured several behavioral responses to song playback: number of vocalizations, flyovers, dives, time spent singing, and closest approach to speaker. All birds reacted aggressively toward playback of both neighbor and stranger songs, but did not respond to the song of a Costa's hummingbird or house finch.

93. BMAA, A NEUROTOXIN IN THE TRADITIONAL CHAMORRO FOOD

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Over a decade ago, researchers hypothesized that an unusual neurotoxic amino acid BMAA, isolated from the seeds of cycad trees, may be the cause of the high levels of ALS/PDC in Guam. It was believed that BMAA was consumed in the traditional diet of the indigenous Chamorros people of Guam, as a byproduct within cycad flours. Early studies suggested that free-BMAA was almost entirely removed in the traditional washing process. However, more recent work suggests that these early studies missed BMAA incorporated into the protein fraction of the flour. We hypothesized that although the concentration of BMAA in the form of free amino acids is very low, there remains a sizable portion of BMAA in the protein fraction of washed cycad flour. We mimicked the traditional Chamorro method of seed preparation to obtain the cycad flour. Next, we quantified the amount of BMAA in both the free and protein bound fractions using HPLC. We found low concentrations of BMAA as a free amino acid in the washed seeds and high levels of BMAA in the protein portions of the flour. The current findings indicate that free BMAA is almost entirely removed during the traditional method of washing, consistent with the early studies. However, there is a large quantity of BMAA that remains in the protein fraction of the cycad flour. We suggest that this represents a significant contribution of BMAA to the traditional diet of the Chamorro people in Guam and supports the original hypothesis suggesting that BMAA is linked to the cause of ALS/PDC.

94. CHARACTERIZING THE UPSTREAM REGULATORY REGION OF BP180

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The lab created a mouse line expressing *dominant negative Clim* (DN Clim) under the control of the *keratin 14 promoter*, which is able to out-compete wild type Clim in binding factors associated with Clim. An expression profile study was done at various time points in development with RNA from these mice, and two genes were down-regulated across all time points. One of these genes was *BP180* or *Collagen XVII.*

BP180 is a transmembranous compcnent of *hemidesmosomes*, attaching structures within *basal keratinocytes*, which stabilize the connection between the epidermis and the dermis by linking the keratin intermediate filament network to the anchoring filaments of the basment membrane. The expression of *BP180* has been detected in skin as well as other tissues such as cornea, umbilical cord, prostate and testis to name a few.

To date, nothing has been reported on the regulatory region of *BP180*. The objective of this project was to characterize the upstream regulatory region of this gene and to determine if Clim and cofactors of Clim are important for its expression. This was done by constructing fragments spanning the 1.35 Kb upstream region of *BP180* by PCR, and cloning these fragments into a luciferase vector. With each vector containing a different piece of the putative regulatory region of *BP180*, they was transiently transfected into *HaCaT cells*, which are human *keratinocytes*, with or without dominant-negative Clim. The efficiency of each fragment to either promote or repress gene expression was then analyzed by *luciferase assays*.

95. AGGRESSION AND BIG HEADS: SEXUAL DIMORPHISM IN HOUSE CRICKETS (*ACHETA DOMESTICUS*)

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Males and females in many species are different as a consequence of the different selective pressures acting on each sex. In species where males engage in combat to defend territories or mates, males tend to have exaggerated morphology or larger body size compared to females. In house crickets, *Acheta domesticus*, male crickets defend resources by engaging in a sequence of behaviors. Mandible flaring is a striking visual display used in cricket fights where males spread their mandibles open. This presumably acts as a visual signal of body size and an indicator of willingness to fight. We tested the hypothesis that sex differences in the signals used for aggressive interactions (females don't mandible flare) will lead to sex differences in the size and shape of the head in house crickets. To test this hypothesis we made linear measurements of body and head size on male and female crickets and utilized geometric morphometric methods to reconstruct sex differences in shape. As predicted, males had larger heads than females and there were significant shape differences. In addition, allometric relationships between head size and body size indicated that head size increases faster than body size in males. Geometric morphometric analysis indicated that the shape differences result in an exaggeration of the mandibular area in males compared to females. These data suggest the differential selective pressures acting on males and females can not only lead to differences in size but also differences in shape related to signal structure and function.

96. DOCUMENTATION OF COYOTES ON THE PALOS VERDES PENINSULA

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Popular knowledge has held that coyotes moved onto the Palos Verdes Peninsula in the mid-1990's, a phenomenon bolstered by residential sightings and complaints about missing cats and other small animals. Despite the general knowledge that coyotes are living on the Peninsula, no scientific studies have been conducted to determine their presence and where exactly they abound. We began a study to investigate the coyotes' existence by surveying for coyote scat and footprints. Our surveys, conducted in the major canyons of Rolling Hills and the Canyons Ecological Preserve of the Portuguese Bend Nature Preserve, revealed the presence of coyote scat and tracks. We will use this initial survey as part of an ongoing study to determine the areas and movement corridors utilized by coyotes throughout the Peninsula. Additionally, we expect to use our results to help residents take proper measures for living harmoniously with coyotes.

97. HAS THE STATEWIDE BAN ON *CAULERPA* SPECIES BEEN EFFECTIVE? A SURVEY OF SOUTHERN CALIFORNIA AQUARIUM RETAIL STORES

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The *Caulerpa taxifolia* invasion in the Mediterranean Sea raised awareness of the potential for introduced seaweeds to impact coastal communities. Subsequent introductions of *C. taxifolia* in southern California in 2000, presumably from the release of aquarium specimens, cost ~$4.5 million for eradication efforts. Besides *C. taxifolia*, other *Caulerpa* species being sold for aquarium use also may have the potential to invade southern Californian and U.S. waters. Surveys of the availability of *Caulerpa* species in southern California aquarium retail stores in 2000–2001 revealed that 26 of 50 stores sold at least one species of *Caulerpa* and seven stores sold *C. taxifolia*. In late 2001, California imposed a ban on the importation, sale, or possession of nine *Caulerpa* species (DFG Code 2300); the City of San Diego expanded these regulations to include all species. To determine the effectiveness of the California ban, we surveyed *Caulerpa* availability at 44 of the southern California retail stores in 2005–2006 sampled in our

previous study. Similar to previous methods, specimens of *Caulerpa* species were purchased, identified, and preserved. Of the 44 stores, 23 sold *Caulerpa* and three stores sold *C. taxifolia*. Three additional stores had *Caulerpa* species in stock but not for sale. These results suggest that the California ban on *Caulerpa* species has not been effective and that the retail aquarium industry continues to represent a potential vector for distributing *Caulerpa* specimens, including *C. taxifolia*. This study underscores the need for outreach and enforcement programs to increase awareness among the aquarium retail industry and aquarium hobbyists.

98. ECOTONE BIODIVERSITY IN THE CHAPARRAL–RIPARIAN TRANSITION

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In Eaton Canyon (Pasadena CA.) plant species diversity was surveyed from the riparian woodland to the chaparral paying close attention to the ecotone between them. The ecotone displayed a higher diversity than either the riparian zone or the chaparral communities alone. Counter to expectations, the riparian zone had the lowest species diversity of the three zones surveyed. The overwhelming presence of the invasive species sticky eupatorium (*Ageratina adenophora*) may be limiting the diversity in the riparian plant community.

99. ETHYLENE AS A POSSIBLE GERMINATION CUE FOR SAND VERBENAS (*ABRONIA* SPP., NYCTAGINACEAE)

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Sand verbenas (*Abronia* spp., Nyctaginaceae) are psammophilous species occurring in open and often disturbed habitats in western North America, especially coastal dune communities along the Pacific coast and sandy desert habitats. Most species are obligate outcrossers which produce anthocarp-surrounded achenes that are wind dispersed. High- rainfall years result in extensive germination and flowering of *Abronia* species in the deserts, however, these species are difficult to germinate in the laboratory. This hinders conservation and restoration efforts for sand verbenas some of which are rare and others of which have been displaced from dune environments by the encroachment of invasive species and human activities. Several of the pretreatments used to enhance germination of *Abronia* species, e.g., stratification, act on ethylene biosynthesis in other taxa. Thus the possibility that ethylene (supplied as the liquid ethephon) could trigger germination was investigated for the perennial *Abronia martima* and the annual *Abronia umbellata*. Germination of achenes from which the anthocarp had been removed exceeded 90% for all concentrations of ethephon tested (10, 100, and 500 μmol l^{-1}) but the rate of germination was highest at 500 μmol l^{-1}. Ethephon treatment (100 μmol l^{-1}) also resulted in germination for *Abronia fragrans* and *Abronia villosa* suggesting that different sand verbenas may have similar dormancy mechanisms. Germination of achenes surrounded by the anthocarp is only slightly increased with ethephon treatment (approximately 10%) indicating a "coat-imposed" dormancy by the anthocarp. Identification of ethylene as a germination cue will facilitate conservation and restoration efforts for sand verbenas.

100. FIRES OF KELVIN CANYON

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The objective for this study was to determine the effects of a surface burn on the soil in Kelvin Canyon. Ten soil pits were dug, five affected by the burn and five relatively unaffected. Over two weeks multiple tests were run on the pits, including pH, drip test for hydrophobic layer, structure, drainage, and water retention difference. Differences in vegetation were also observed. Some of the tests revealed no statistically significant differences. Percent clay and water retention differences do not vary from burned to unaffected pits, and all sites are classified as well-drained. Soil pH in the surface horizon of burned soils is more alkaline than the surface horizon of unaffected soil. Another result of a burn is the formation of

a hydrophobic layer, formed when hydrophobic compounds in the soil secrete a waxy substance which coats soil particles. The hydrophobic layer is present in all burned pits, but absent in pits that were not burned. Sites that were not scorched have a higher percentage of native vegetation and more total percent cover than burned sites. Invasive annuals quickly colonized the burned areas, but perennial natives show some signs of recovery. Burned sites have darker colors in their surface horizon than unaffected sites. Structure is very similar in all horizons except the surface, where burned pits tend to have angular blocky shape and unaffected pits tend to be granular.

101. INFLUENCE OF ANTHROPOGENIC NOISE ON SONG STRUCTURE IN ANNA'S AND COSTA'S HUMMINGBIRDS

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Urbanization causes an increase in human-created (anthropogenic) noise, e.g. from traffic and power lines. This increased noise may be a problem in habitats where animals depend on sound transmission for survival and reproduction. Songbirds have been shown to raise the frequency of their song above ambient noise, however hummingbirds are not songbirds. Increased anthropogenic noise may interfere with the behavior of male hummingbirds, as they use song to defend their feeding and breeding territories and to attract potential mates. It is possible that hummingbirds are unable to alter their song in response to changes in noise levels, in which case anthropogenic noise could have a negative effect on hummingbirds^1 reproductive success. We analyzed the song of male Anna^{1}s and Costa^{1}s hummingbirds (Calypte anna and Calypte costae, respectively), to determine whether they alter song parameters (frequency, amplitude, power and duration) in response to increased ambient noise. We also looked at possible behavioral changes in the presence of sources of intermittent noise, such as cars.

102. THE EFFECTS OF HYDROPERIOD ON THE GROWTH RATES OF FLORIDA FLAGFISH, *JORDANELLA FLORIDAE*, IN THE FLORIDA EVERGLADES

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Ecologists often assume that certain environmental conditions are detrimental to the fitness of a species based on studies of other species occupying the same ecological niche. In order to determine the effects that environmental pressures impose upon a particular species, their life history parameters should be examined over a range of presumably favorable and unfavorable conditions. In this study, we examined the effects of hydroperiod on the growth rates of Florida flagfish, *Jordanella floridae*, in the Florida Everglades. Areas with short hydroperiods often force fishes and other aquatic organisms to emigrate to areas with longer hydroperiods in order to seek suitable habitat. The energy normally reserved for growth is thus expended on these seasonal migrations. In contrast, our data show that there is no significant relationship between hydroperiod and the growth rates of *J. floridae*. Additionally, we found that juveniles experience higher growth rates in Shark River Slough than in the Water Conservation Areas but slightly slower rates of growth after maturation. We conclude that hydroperiod has relatively little effect on *J. floridae* and believe that its tolerance of shallow depths, low oxygen levels, and crowded conditions allows this species to remain in or near areas that experience frequent dry-down events. This study illustrates the need to determine species-specific responses to presumably stressful environmental conditions.

103. GEOCHRONOLOGY AND PALEOENVIRONMENT OF PLUVIAL HARPER LAKE, MOJAVE DESERT, CALIFORNIA

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The Mojave River is a well-known recorder of Southern California paleoclimate with a complex paleohydrology and past terminations in pluvial (upstream to downstream) Harper (Harper basin only), Manix (Afton, Coyote & Troy basins), Mojave (Soda & Silver basins) lakes over the last 30,000 years. Previous studies yielded uncalibrated radiocarbon ages ranging from 24 ka yrs B.P. to > 30 ka yrs BP for lake high stand deposits near 656 m elevation. Based on several studies, the Mojave River: 1) flowed simultaneously into Harper and Manix lakes ~30 ka; 2) flowed exclusively into Manix Lake 28–25 ka; 3) resumed simultaneous flow into Harper and Manix lakes, reaching the highstand and then receding ~25 ka. However, the radiocarbon dates do not encompass the complete section, thus the maximum age of Harper Lake is unknown. Here we present geologic mapping (1:12,000), a measured stratigraphic section and radiocarbon ages from the Red Hill area. The 2.1-m-thick continuous stratigraphic section is near the high-stand elevation and comprised of interbedded sand, silt and silty sand capped by a 0.6-m-thick sequence of carbonate mud. The base of the section nonconformably lies on quartz monzonite. Four *Anodonta californiensis* shell horizons were sampled for radiocarbon dating. Seven uncalibrated radiocarbon ages range from 29,210 ± 240 to 35,230 ± 490 ^{14}C yrs B.P. Our radiocarbon ages and the continuity of the section support a single Harper Lake highstand between 35 and 29 ka with no subsequent highstand at 25 ka.

104. POSSIBLE HEAT SOURCES FOR CRANIAL ENDOTHERMY IN THE YELLOWFIN TUNA

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Endothermic tunas can produce heat internally and conserve heat to elevate the temperature of the eye and brain above water temperature, a characteristic known as cranial endothermy. Although elevated cranial temperatures have been measured in tunas, the mechanism whereby heat is produced for cranial endothermy in these fishes is unknown. The purpose of this project was to test the hypothesis that the heat source is one or more of the six extrinsic ocular muscles in tunas. Ocular muscle samples from the yellowfin tuna (*Thunnus albacares*) and the chub mackerel (*Scomber japonicus*), an ectothermic scombrid fish, were obtained from fish collected off the coast of Panama and southern California. The relative mass of each muscle was measured and expressed as a percentage of total eye mass. The capacity for metabolic heat production in each ocular muscle was quantified by measuring the activity of the mitochondrial enzyme citrate synthase (CS). The medial rectus muscle was found to be the largest of the six ocular muscles in both species. There was no significant difference in CS activity among the six ocular muscles in the yellowfin tuna. The lateral rectus muscle in the chub mackerel had the highest CS value of all the ocular muscles, indicating a high heat production capacity. Overall, ocular muscle CS activities were higher in the chub mackerel than in the yellowfin tuna, but relative muscle masses were greater in the tuna. The results suggest that all six extra-ocular muscles may contribute to cranial endothermy in tunas.

105. CONTROLS ON PLANT GAS EXCHANGE ACROSS A GRASSLAND TO SHRUBLAND GRADIENT IN OWENS VALLEY, CALIFORNIA

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It has been suggested that woody encroachment is occurring in Owens Valley, California due to water stress caused by groundwater pumping and redistribution that has been occurring for the last hundred years. However, this linkage has not been solidly demonstrated. I tested the hypothesis that changes in water availability may facilitate irreversible woody encroachment by choosing sites along a vegetational gradient, from grassland to predominately shrubland. At each site I took chemical and isotopic composition measurements of plants and soil, ground and stem water isotopic measurements, and physiological measurements of the dominant species in each site. Grass gas exchange in the grassland site was high at the beginning of the season, while at the intermediate and shrubland sites grass gas exchange remained low and constant throughout the season. This difference was not attributable to groundwater use, water potential, or leaf carbon to nitrogen ratios. Soil organic content was greatest at the grassland site and the least at the shrubland site, and the soil nitrogen was most enriched at the shrubland site. In all species, leaf nitrogen loss was evident. Leaf carbon to nitrogen (C:N) ratios were greatest in the shrubland except for the halophytic shrubs, where leaf C:N did not differ between sites. Leaf nitrogen in the shrubs, and especially in the halophytic shrubs, was more enriched than the grasses, suggesting that shrubs may be more competitive at taking up enriched soil nitrogen, possibly facilitating woody encroachment through a decline in grasses from sites with low and enriched nitrogen content.

106. THE EFFECTS OF GLYPHOSATE ON PROLIFERATION OF *RANA PIPIENS* SPLENOCYTES STIMULATED WITH CON A AND PHA

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The decline of amphibian populations, beginning in the 1970s, has become an area of major concern. Among the possible explanations for this worldwide decline, pesticide exposure has gained significant attention in recent years. Glyphosate (active ingredient in the herbicide Roundup^{TM}) is a herbicide that is frequently in many countries to control vegetation in both cropland and aquatic environments. The effects of glyphosate on the proliferation of *Rana pipiens* (Leopard frog) splenocytes stimulated with mitogens Concanavalin A (ConA) and Phytohemagglutinin-M (PHA) were studied. Splenocytes were exposed to 20 µg/ml of each mitogen and a range of 2.5 µg/ml to 5000 µg/ml of glyphosate. Cell counts were used to determine effects on proliferation. Our data show a consistent decrease in the number of splenocytes exposed to glyphosate, whether proliferation was stimulated by Con A or PHA. These results suggest that glyphosate can alter the immune response of leopard frogs.

107. 10-YEAR ASSESSMENT OF SOFT-BOTTOM MACROBENTHIC ASSEMBLAGES OFF THE COAST OF SAN DIEGO

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The City of San Diego has conducted regional benthic surveys of the continental shelf and slope off San Diego since 1994. The main objectives of these surveys are: (1) to characterize benthic conditions for the coastal region off San Diego; (2) to characterize the ecological health of the marine benthos in the area; (3) to gain a better understanding of regional conditions in order to distinguish between areas impacted by anthropogenic or natural events. The study area ranges from northern San Diego County south to the US/Mexico border. During the summers of 1994 through 2003 a total of 324 randomly selected sites were sampled at depths ranging from 9 to 461 m. Patterns of macrobenthic community structure and the distribution of various environmental parameters were addressed using a suite of univariate and multivariate statistics. Using these analyses we identified 10 main macrobenthic assemblages during this 10-year period. A combination of cluster mapping and ordination by MDS discriminated these assemblages as stratified along depth contours, with no apparent spatial patterns relative to point source inputs. Although results from the univariate analyses were variable, values were comparable to historical ranges recorded for the entire Southern California Bight. Overall, these data suggest that the structure of benthic communities off San Diego has remained stable and not changed substantially in recent years.

108. LENGTH, WEIGHT AND GENDER COMPARISONS OF THE BAY PIPEFISH (*SYNGNATHUS LEPTORHYNCHUS*) FROM THREE CENTRAL CALIFORNIA COASTAL LOCATIONS

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The bay pipefish, *Syngnathus leptorhynchus*, is commonly found in eelgrass beds along the Pacific coast from Alaska to Baja California. Despite numerous studies on its reproductive behavior, little is known about the size patterns of this species. This study examined the correlation between standard length and wet weight of this species from three locations along the central California coast, as well as the gender composition in each location. Individuals captured ranged from 52.75 mm to 270.82 mm in standard length, and from 0.13 g to 8.31 g in wet weight. Correlation tests revealed the standard lengths and wet weights of the fishes in each location were significantly correlated. Average wet weight of females was slightly larger than average weight of males in all three locations. However, in two respective locations, average standard lengths of females were larger than males. In addition, the sex ratio was skewed towards females in these two locations; nevertheless, this is not sufficient to determine if males are in short supply in these locations.

109. PREDATION IN EELGRASS BEDS: DO TROPHIC MANIPULATIONS RESULT IN CASCADING EFFECTS?

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Eelgrass (*Zostera marina*), common to bays and estuaries in California, provides important nursery grounds to many fishes and invertebrates. Although much work has been conducted on this and other seagrasses, very little is known about ecosystem function via trophic interactions in nature that may ultimately impact the health of eelgrass. The aim of this project is to explore the importance of small microcarnivorous fishes in the functioning of eelgrass ecosystems. We are using caging experiments to manipulate predator density and diversity, and observe the responses of organisms at lower trophic levels. The proposed experiments will provide managers important information that may aid in the restoration and conservation of these declining essential fish habitats. In Summer 2006, 18 prototype cages were constructed and tested for use in predator manipulations. In addition, beach seines were used to evaluate the diets and relative densities of small carnivorous fishes common to eelgrass habitats within San Diego Bay. A pilot experiment was also completed testing the effectiveness of cage designs and sampling methods. Cages appear to generally be well designed; however, the mesh used (3 mm) exerted significant shading effects on seagrass. A new mesh has been employed that results in minimal shading while excluding most small fishes. Predator manipulation experiments are scheduled to be conducted in Summer 2007.

110. THE EFFECTS OF STRESS AND EXERCISE ON THE EXPRESSION OF BCL-2 ASSOCIATED PROTEIN X AND BRAIN-DERIVED NEUROTROPHIC FACTOR

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It was previously shown that chronic restraint stress induces an upregulation of activated Bcl-2 Associated protein X (Bax), which promotes neuronal apoptosis in its oligomer state. Exercise lowered levels of Bax, and it was hypothesized that this was due to elevation in trophic factor expression, in particular brain-derived neurotrophic factor (BDNF). BDNF, markedly expressed in the hippocampus of the brain, is a protein that serves as a neurotransmitter regulator and aids in long-term potentiation and learning. BDNF can also activate phosphatidylinositol 3-kinase, mitogen-associated protein kinase, and other cell survival pathways; it has the potential to protect against stress-induced harm in neurons. In the current study, rat models were subjected to acute stress by immobilization and/or allowed to exercise by a running wheel 14 days prior. Four treatment groups were compared: stress-only, exercise-only, exercise with stress, and control (with neither stress nor exercise). Cortical homogenates underwent non-sodium dodecyl sulfate polyacrylamide gel electrophoresis and western blotting for Bax, and hippocampal BDNF mRNA levels were analyzed via *in-situ* hybridization. No statistically significant differences were seen in the activated Bax levels. In the CA3 region of the hippocampus, the exercise-only group showed higher BDNF mRNA levels than did those of the stress-only group. Furthermore, the levels of BDNF in either the exercise-only or stress-only treatment were directly opposite the levels found of Bax found previously in a chronic stress study. These data suggest that BDNF plays some role in countering the harmful effects of stress.

111. FEEDING RATES OF NATIVE CONSUMERS ON INTRODUCED AND NATIVE SEAWEEDS ON URBAN SOUTHERN CALIFORNIA SHORES

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Understanding the impacts of non-indigenous species (NIS) is crucial to the development of management approaches designed to preserve marine biodiversity and ecosystem functioning. On many southern Californian shores, NIS of seaweeds are abundant and important contributors to community primary production. Yet, little is known about the roles of these NIS in intertidal food webs. To address this, we are conducting experimental studies to determine the attractiveness of NIS by comparing the feeding rates of native algal consumers in single-food trials on NIS and native seaweeds. Algal-eating, native consumers include the sea hare *Aplysia californica*, the snails *Lithopoma undosum* and *Tegula aureotincta*, the crab *Pachygrapsus crassipes*, and the urchin *Strongylocentrotus purpuratus*. We selected NIS of seaweeds with different periods of residency in local waters, including species: 1) with a >25 year history of population establishment (*Sargassum muticum* and *Lomentaria hakodatensis*), 2) that have appeared in the last 5 years (*Caulacanthus ustulatus*, *Sargassum filicinum*, and *Undaria pinnatifida*), and 3) have the potential to become invasive (*Caulerpa racemosa* and *Grateloupia turuturu*). Preliminary results suggest that feeding rates of native consumers are low for NIS of seaweeds relative to preferred native seaweeds. Currently, little is known about interactions between NIS of seaweeds and native consumers or how these consumers might be responding to shifts in food availability resulting from introduced species. We hope to improve understanding of the roles being played by NIS of seaweeds in intertidal food webs and shed light on ecosystem-level responses to seaweed introductions in urban southern Californian habitats.

112. PREDICTORS OF SUCCESSION IN A CHRONOSEQUENCE OF *IMPERATA* INFESTED COMMUNITIES

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Lowland tropical rainforests are rapidly disappearing due to fire, logging, and agriculture. Research and conservation efforts are urgently needed, especially in understudied areas like Borneo, Indonesia. Borneo is the world's third largest island and is part of the Sundaland Biodiversity Hotspot. It is also home to many endangered species, including orangutans, which further increases the ecological imperative to study this area. Succession and reforestation efforts in Southeast Asian rainforests have been hindered by the invasion of *Imperata cylindrica*, which is one of the ten worst weedy species in the world and often creates a fire climax community. Most research on *Imperata* control has focused on restoring the land to create commercial plantations. By contrast, little research has been done on natural succession in *Imperata* grasslands or on restoring these grasslands to secondary forest. For this study, plots have been established in a chronosequence of *Imperata* infested sites in Tanjung Puting National Park in Central Kalimantan. It will be determined if land-use and fire history are good predictors of succession in these communities. Also, some plots have been planted with indigenous tree species using different reforestation methods to assess their potential in preventing temporary suppression or permanent deflection of succession. Plots will continue to be monitored for seedling survival and plant cover change. Additionally, climate data and GIS and remote sensing will be used to assess spatiotemporal patterns and to predict future land-use change on a regional basis.

113. THE EFFECTS OF SODIUM BUTYRATE ON THE ORGANIZATION OF ACTIN FILAMENTS IN U87MG BRAIN TUMOR CELLS

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Actin is an important biological component of the cell and is responsible for cell structure, division and motility which is crucial in cancer cell metastasis. This study examines the effects of sodium butyrate (NaB) on actin filament organization of U87MG brain tumor cells. Two treatment groups, cells treated with NaB for 5 days (5 dB) and cells treated chronically with NaB for longer than 12 days (ChB), were compared to an untreated control group (NoB). All three groups were prepared for fluorescent microscopy by using 4% paraformaldehyde to fix the cells. First, it is necessary to fix the cells in order to protect them from damage caused by reagents used throughout the staining procedure. Next, the cells were permeabilized with the detergent 0.1% Triton X-100. Oregon Green phalloidin in Phosphate Buffered Saline, containing 1.0% bovine serum albumin used as a blocking agent to reduce non-specific binding,

was used to stain the cells for 20 minutes at room temperature. The cells were then mounted onto a slide and viewed using a Nikon Eclipse E400. The results indicated that overall cell shape was affected in the two treatment groups when compared to the control group. 5 day NaB treated cells showed degeneration of cell structure and cell-cell contacts, while the chronically treated cells maintained prominent cell processes and structure as seen by long, invasive projections. This is important in the study of cancer cell metastasis because degenerative cell structure and cell-cell contacts could allow cells to travel farther whereas cells that have invasive projections are anchored down and are unable to migrate. The role of actin in the cell processes are still under investigation. (This research was supported by a grant from the Ryckman Endowment Student Research Fund at La Sierra University)

114. HYPOCHLORITE-INDUCED DEATH REVEALS THAT MICROPYLAR CELL DIVISION IS NOT NECESSARY FOR DEVELOPMENT OF *SPATHOGLOTTIS PLICATA* SEEDLINGS

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During embryogenesis in flowering plants, the embryo typically develops with a distinct shoot/root axis. In contrast, embryos of seed from the orchid, *Spathoglottis plicata*, tend to show vague indication where the shoot apex is located. It seems that smaller cells located at the proximal/chalazal end of the embryo designate the shoot apex, although it is unclear whether cells in the distal/micropylar region also play a role in seedling establishment. In this work, we show that exposing the micropylar region of the orchid seed embryo to high levels of chlorine will cause death of the embryo and result in bright green autofluorescence. However, lower chlorine treatments will partially affect the embryo, leaving a fluorescent stub in the seedling. Preliminary growth data suggests that this region is not going through cell division. Thus in *Spathoglottis plicata*, micropylar embryonic cells may not be required for increased cell mass during seedling development.

115. THE EFFECTS OF AN INVASIVE PLANT SPECIES, *VINCA MAJOR*, ON ARTHROPOD COMMUNITIES IN RIPARIAN HABITAT AT STARR RANCH AUDUBON SANCTUARY, CALIFORNIA

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Terrestrial arthropods play important roles as decomposers, nutrient recyclers, herbivores, predators, and pollinators. Invasive plants can alter the biodiversity of habitats and arthropods are especially sensitive to such changes. The plant *Vinca major* is an invasive species in southern California and is particularly successful in riparian areas. Understanding how invasive species affect arthropods is important in maintaining biodiversity and the structure of native ecosystems. In this study, we examined the impact of *V. major* on arthropod communities. We hypothesized that arthropod abundance and species richness would be impacted by *V. major* because of changes in the composition in the plant community and the associated changes in habitat structure. Arthropod abundance and species richness were measured along a riparian habitat in non-invaded sites and sites invaded by *V. major* at Starr Ranch Audubon Sanctuary in Orange County, California. Over the course of 36 hours, terrestrial arthropods were captured using 9 pitfall traps in 3 m × 3 m plots (6 sites total). We categorized arthropods into morphospecies, species identification based on morphological similarities, and counted the number of individuals of each morphospecies. We also identified the order of each morphospecies. There were significantly more orders of arthropods from non-invaded sites compared to invaded sites. However, arthropod abundance was generally higher in *Vinca*-invaded sites. These results indicate that non-invaded sites have a greater diversity of arthropods while invaded sites have lower diversity with higher abundance. This supports the hypothesis that invasive plants can alter arthropod communities.

116. THE POPULATION GENETICS OF ROUND STINGRAYS FROM SOUTHERN CALIFORNIA ASSESSED BY MICROSATELLITE MARKERS

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This study aims to determine whether the genetic population structure of round stingrays (*Urobatis halleri*) near a warm water outfall in Seal Beach, CA shows either seasonal or annual variation. It also aims to elucidate if a homogeneous population structure exists in the Southern California Bight, utilizing samples that have been collected from the Seal Beach Naval Weapons Station wetlands and San Diego Bay, CA. Highly polymorphic STR primer pairs have been developed for four loci, and analysis is nearly complete for one locus, Uha 170. This locus shows no variation over seasons or over 5 years ($F=0.7221$, $p=0.6534$) at Seal Beach. Partial analysis of the Weapons Station and San Diego samples indicates similar allele distributions to that of Seal Beach suggesting a large, homogeneous population. Primary data from the other three loci thus far show similar results to the Uha 170. Tissue samples from round stingrays found across geographic barriers (north of Point Conception, the Gulf of California, and Santa Catalina Island) are also currently being collected and will be tested to determine if they display different allelic frequencies to those found in the Southern California Bight.

117. FEEDING PREFERENCES OF THE MARINE GASTROPOD *APLYSIA VACCARIA*

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Herbivores can exert a large impact on algal community structure. Understanding herbivore feeding preferences provides insight into their relative importance in structuring their communities. *Aplysia vaccaria* is a large herbivorous marine gastropod found along the California coast. Little is known about this species regarding its feeding ecology due to its temporally and spatially patchy distribution. To determine if *A. vaccaria* exhibits feeding preferences, we performed a series of paired-choice feeding trials. The algae used include two brown kelps commonly found in its habitat, *Egregia menziesii* and *Macrosystis pyrifera*, along with the red algae *Plocamium cartilagineum*, which is a primary food source for its cousin *A. californica*. We hypothesized that *E. menziesii* would be preferred over other algal species because it is prevalent in *A. vaccaria's* habitat and is thought to induce larval metamorphosis. After feeding trials, we analyzed for preferences by comparing differences in the amount (g) of algae consumed using paired t-tests. *E. menziesii* was significantly preferred over *P. cartilagineum*, while there was no significant difference in consumption between *E. menziesii* versus *M. pyrifera*. Additional feeding trials will be conducted using all combinations of the above algal species paired with *Ulva californica* and *Laminaria farlowii*. Studying the feeding ecology of *A. vaccaria* may determine its importance as a grazer as well as any disturbances it may create in marine algal communities.

118. INDUCED OXIDATIVE STRESS DECREASES MINERALIZATION IN BONE-LIKE CELL CULTURES

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The maintenance of appropriate bone mass is critical in sustaining optimum bone health. Many factors such as hormones, diet, genetics and oxidative stress influence bone mass and mineralization. Osteoporosis is a bone disorder characterized by thinning of bone mass with a reduction in calcium and bone proteins. It is well known that oxidative stress induces apoptosis in many cell types. This compromises the ability of specific bone cells (osteoblasts) to mineralize properly. Cellular mechanisms leading to the response of osteoblasts to oxidative stress and subsequent decrease in mineralization are incompletely understood. This study investigates the effect of camptothecin, a known oxidative stressor and inducer of apoptosis, on mineralization in an osteoblast-like cell line, UMR 106-01 BSP (UMR cells). UMR cells are rat osteosarcoma cells that exhibit many of the morphological and physiological characteristics of primary osteoblasts, including the production of the enzyme alkaline phosphatase. This enzyme is essential in the mineralization of a bone-like matrix secreted by osteoblasts *in vitro*. When UMR cell cultures were treated with camptothecin, they showed a concentration-dependent decrease in mineralization that correlated with a decrease in alkaline phosphatase concentration. These findings suggest that oxidative stress negatively impacts bone mineralization and general bone health. Further studies are necessary to elucidate the cellular mechanisms involved in osteoblastic responses to oxidative stress and to identify countermeasures can be employed to mitigate decreased mineralization.

119. COMPARISON OF THREE ANALYTICAL METHODS TO DETERMINE CHLOROPHYLL CONCENTRATION IN THE OCEAN

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Understanding variations in phytoplankton abundance is an important aspect of ocean monitoring. Variations can indicate algal blooms, which can be toxic and affect the health of humans and wildlife. Chlorophyll concentrations are commonly used to monitor these changes. Sensors are now available that measure chlorophyll concentrations in real-time, enabling an accelerated ability to recognize harmful algal blooms. CICORE is involved in an effort to monitor water quality variations, including chlorophyll, in real-time along the California coast via in-situ sensors. Our purpose was to compare High Profile Liquid Chromatography (HPLC) and fluorometry to enable a more accurate interpretation of the data set obtained by our sensor. A Turner Bench top 10-AU Fluorometer, a Beckman HPLC system, and a Turner Chlorophyll a in-situ sensor were used to examine water in Fish Harbor, Terminal Island. Side-by-side comparisons supported the literature in concluding that all three methods provided a qualitative, not quantitative, measurement of chlorophyll concentrations. Additional experiments focused on the interference of degradation products, and sample storage and extraction methods. Degradation products could be minimized in bench top fluorometry by acidification, were accounted for in HPLC (Yacobi, 1996), and were unaddressed by the in-situ sensor. Storage method showed that the rate of degradation varied depending on storage method. Extraction experiments showed that residual chlorophyll remained in the filter and further experimentation to determine more effective extraction should be performed. These results emphasize the importance of establishing standard methodology for analyzing and reporting chlorophyll concentrations so data can be comparable across regions and states.

120. COMMUNITY STRUCTURE OF MACROPARASITES OF THE VERMILION ROCKFISH, *SEBASTES MINIATUS*, FROM RECREATIONAL FISHING CATCHES OF SAN QUINTÍN, BAJA CALIFORNIA, MEXICO

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The vermilion rockfish, red rock cod or named simply "reds", *Sebastes miniatus* (Jordan and Gilbert 1880), is a common fish species that is caught from, both, the coastal commercial and the recreational fishing from California and northern Baja California. We studied the macroparasites (ecto and endo) from the vermilion rockfish that was captured by the recreational fishing from San Quintín, Baja California, México. Six bimonthly collections were realized during 2005, and 213 vermilions rockfishes were analyzed (Average 436 mm LT ± 68.9 SD, size interval 280–610 mm). All vermilions were parasited with one or more parasites. A number of 29,639 individuals of parasites were collected belonging to 12 species ranging in prevalence from 3.4% (*Clavella* sp) to 97% (*Megalobenedenia* sp) and 98% (*Clavellisa* sp). The most abundant parasite was *Botriocephalus* sp with 14,879 individuals; *Hysterothylacium* sp was second with 6,373 individuals, and followed by *Microcotyle sebastes* with 2,766 individuals. In same order, these parasites were present in 17.2%, 31.5%, and 18.2% of the total vermilion rockfishes. The mean intensity of individual parasite species on *S. miniatus* ranged from 0.1, *Pseudoterranova* sp to 425.1, *Botriocephalus* sp. The range of intensity of the parasite *Hysterothylacium* sp was from 1 to 2,231 individuals on a single fish.

121. TEMPORAL AND SPATIAL VARIATION IN SETTLEMENT OF *OSTREA CONCHAPHILA* IN NEWPORT BAY, CALIFORNIA

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Ostrea conchaphila, is the only oyster native to the west coast of the United States. Over-harvesting in the early 1900s paired with pollution from pulp mills led to massive population crashes. There are still remnant populations throughout its range and some restoration efforts are currently occurring in areas between northern California and Washington. Before planning to restore populations of *O. conchaphila*, it would be important to learn about constraints on current population growth. For example, knowledge about temporal and spatial variation of *O. conchaphila* larval settlement could potentially help maximize the collection of spat in order to enhance settlement within an existing population. Settlement of *O. conchaphila* was assayed at six sites throughout the bay using settlement tiles that were collected every spring tide. We hypothesized that settlement would vary both spatially and temporally among populations located within Newport Bay, California. Preliminary findings show that settlement varied significantly among sites, with highest settlement typically occurring at sites in the upper bay. We also found that settlement varied temporally with maximal settlement occurring in mid-August at most sites. Future studies will attempt to pinpoint variation in growth rates and survivorship among settlers from sites throughout Newport Bay in an effort to understand what factors limit population density.

122. THE EFFECTS OF SODIUM BUTYRATE ON U87MG BRAIN TUMOR CELL MIGRATION AND INVASION

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Differentiation drugs influence tumor cell behavior. They decrease proliferation and change the types of matrix metalloproteinases secreted by cells. This study investigates the effects of one differentiation drug, sodium butyrate (NaB), on the migration and invasion of U87MG brain tumor cells. Two treatment groups, cells treated with NaB for 5 days (5 dB) and cells treated chronically with NaB for longer than 12 days (ChB) were compared to an untreated control group. Migration was studied using a wound assay where the migration rate of cells into the wound area was measured. Preliminary wound assays show that of the three cell groups, the 5 dB cells had the highest migration rate while ChB cells had the lowest migration rate. Invasion was studied using a Transwell Invasion assay where cells must migrate through 8 um pores of a membrane insert (Becton Dickinson) containing 0.2 mg/ml Collagen I . The results of preliminary invasion assays indicate that 5 dB cells have a higher invasion rate relative to control and ChB cells when passing through a collagen I barrier. These studies suggest that chronic treatment with NaB may help suppress tumor metastasis however further studies are needed to understand the increased migration and invasion caused by NaB after 5 days of treatment. (This research was supported by a grant from the Ryckman Endowment Student Research Fund at La Sierra University)

123. ANTHROPOGENIC CONTROLS OF HARMFUL PHYTOPLANKTON TAXA IN SANTA MONICA BAY

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Anthropogenic alterations of coastal waters due to wastewater discharge and surface runoff cause shifts in phytoplankton biomass, productivity, and community structure. We present data that reveal dramatic increases in production and a shift to a harmful species, *Lingulodinium polyedra*, following the release of secondary effluent to surface waters of Santa Monica Bay. Further, we introduce a framework to test the mechanisms by which phytoplankton communities are altered in nutrient-rich freshwater plumes, with a particular emphasis on stormwater. This work highlights the role of coastal development in the dynamics of harmful algal blooms and the importance of improving management of wastewater and urban runoff.

124. EFFECT OF TEMPERATURE AND RATION LEVEL ON THE GROWTH OF YOUNG-OF-THE YEAR COHO SALMON (*ONCORHYNCHUS KISUTCH*): A COMPARISON BETWEEN OREGON AND CENTRAL CALIFORNIA STOCKS

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Coho salmon (*Oncorhynchus kisutch*) range from Scott Creek, Santa Cruz County, California to Alaska, across the Bering Sea and down to northern Japan. The Scott Creek (37°N) population constitutes the southernmost coho population in North America and is listed as endangered under the Endangered Species Act. We tested the effect of water temperature and ration level on the growth rate of these fish compared to a more northern population from the Salmon River, Oregon (45°N) grown under the same conditions. Fish were reared at 8, 12, and 17°C for two months at a ration level of either 1% or 2% of total tank biomass. Fish were weighed and measured every two weeks and rations were adjusted upwards at this time. Based on the water temperatures these fish experience during their first year in the stream we hypothesized that the Salmon River coho would grow better at 8°C; both stocks would grow equally at 12°C; and Scott Creek fish would grow better at 17°C. Our results show that the Salmon River coho grow better at all temperatures and ration levels than the Scott Creek coho.

125. PERCENT METHYLATION AND ITS RELATIONSHIP WITH AGING

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Aging, tissue deteriorating over time was evaluated using DNA methylation, a level of control, which regulates gene expression by adding a methyl group to cytosine, one of the bases of DNA. By measuring the DNA methylation patterns from the human hair follicle and buccal cells in the CpG islands of the CSX gene, it is hypothesized that as aging develops, there are numerous incorrect gene expressions causing an increase in DNA methylation patterns. Thus, the goal of this study is to determine an individual's age by calculating the percentage of methylation found in DNA of patient hair strands and in buccal cells. Using bisulfite treatment, which is necessary to determine the presence of DNA methylation, unmethylated cytosine is converted into uracil in the extracted DNA. DNA extracted from hairs and buccal cells were amplified by PCR and cloned for reading. Results for hair show inconsistency in DNA methylation patterns for age groups, while results for buccal cells remain inconclusive.

126. DETERMINING THE TIMING AND OFFSET OF SECONDARY NORMAL FAULTS IN THE KIT FOX HILLS ADJACENT THE NORTHERN DEATH VALLEY FAULT ZONE

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The Kit Fox Hills of Death Valley National Park California are composed of late Tertiary and Quaternary sediments uplifted by folding and faulting along the right-lateral Northern Death Valley Fault Zone (NDVFZ). Along the NDVFZ are arcuate normal faults that extend away from the fault at ~45 degree angle, and then parallel the fault zone. The purpose of this paper is to determine the offset and age of these normal faults by the morphological degradation. Three fault scarp faces were examined and their profiles measured. Two of the three were found to have a maximum angle less than the angle of repose and thus amenable to the Bucknam and Anderson method. Scarp 1 was found to be between 6–8 ka and scarp 2 plotted a range of 800 years – 1.5 ka. The third fault scarp has a 62 degree scarp face indicating either a relatively young scarp or high cohesion, carbonate-cemented soils. Machette (Machette 2001) found a scarp in Death Valley that is between 500–600 years in age. Scarp 3 is the only scarp in the Kit Fox Hills with a free face and may be a result of cemented soils. With too many variables attached to scarp 3, finding a relative age will have to remain undetermined. In doing this investigation it will greater our understanding of secondary fault ruptures along fault zones, which could improve the safety of buildings near faults as well as providing insight of the tectonics of the Death Valley fault region.

127. DEVELOPMENT OF JAW MUSCULO-SKELETAL STRUCTURE IN THE YELLOWFIN TUNA AND THE EASTERN PACIFIC BONITO

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The purpose of this study was to describe and compare the development of the jaw muscles and skeletal structure in larval yellowfin tuna (*Thunnus albacares*) and eastern Pacific bonito (*Sarda chiliensis*). The

bonitos (42.5–210.5 hours post spawning) were obtained from the Monterey Bay Aquarium and were raised at 24°C. Yellowfin tunas (24–445.5 hours post spawning) were raised at 27°C at the Inter-American Tropical Tuna Commission Achotines Laboratory in Panama. Immunohistochemical staining of slow muscle myosin and fluorescence and confocal microscopy were used to detect muscles in the jaw region. The development of the jaw skeleton was examined using samples that were cleared and stained, so that cartilage stained blue and bone stained red. The jaw was predominantly composed of cartilage up to 96 hours post spawning in larval yellowfin tuna and up to 162 hours post spawning in the bonito. Generally, yellowfin tuna developed at a faster rate than the bonito, in part due to the differences in water temperature, and ossification of the cartilage within the jaw region is also more rapid. During development, the jaw musculature increased in size in both species, but the lower jaw muscles were more extended and pronounced in the eastern Pacfic bonito compared with the yellowfin tuna. Because jaw musculo-skeletal structure affects feeding effectiveness, this study will lead to a better understanding of feeding and survival in the critical larval stage.

128. MORPHOLOGICAL VARIATION OF *YUCCA BREVIFOLIA* (AGAVACEAE) AMONG SEVEN POPULATIONS IN THE MOJAVE DESERT

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The current distribution of *Yucca brevifolia* Engelm. forms a disjunct ring around the Mojave Desert. which may represent the result of post-glacial migration that now restricts gene flow between eastern and western populations. We examined the tree and leaf morphology of seven populations of *Yucca brevifolia* spanning the Mojave Desert. Two taxonomic varieties, *Y. brevifolia* var. *jaegeriana* and *Y. brevifolia* var. *brevifolia*, are commonly distinguished based on general morphological characteristics including tree and leaf sizes. Morphological variance among populations was expected to be minimal within eastern or western regions, while variance between regions was expected to be greater. Key taxonomic characteristics were compared among populations using ANOVA, and broader evaluation utilized principal component analyses. Tree and leaf characters of three populations conformed to the classification of *Y. brevifolia* var. *jaegeriana*; one population showed characteristics of var. *jaegeriana* for leaf characters but not for trunk size, and three western populations exhibited characters similar to the more widespread *Y. brevifolia* var. *brevifolia*. Principal component analysis showed a clear separation in morphology between populations in the western and eastern regions of the desert. Climate variables did not correlate with morphological traits, suggesting that these morphological patterns may be a result of gene flow rather than common climate factors.

129. THE ACETYLCHOLINESTERASE INHIBITOR MALATHION IS NOT TOXIC TO THYMOCYTES, BUT MAY ALTER THE DEVELOPMENTAL PROGRAM AT LOW DOSES

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The incidence of allergy and asthma among children under five years old has risen 150% in the last two decades, and environmental pollutants are suspected to be contributors to this rise in incidence. Environmental pollutants, such as pesticides, are known to have a negative impact on the environment as well as many living organisms. However, there are a limited number of studies that have investigated the impact pesticides have on the immune system of mammals. Futhermore, even fewer studies exist that examine the impact of environmental toxicants on the immune system of the developing embryo and young animal, though the immune systems of the young are more vulnerable to perturbation than that of adults. Therefore risk assessment studies addressing fetal immune development are important tools for better understanding whether pesticides and other environmental toxicants contribute to immune system diseases that are widely common today. We set up an in vitro model system to assess the risk of exposure to the pesticide Malathion. Malathion was chosen for the study because of its widespread use in agriculture and the known role it plays as an acetylcholinesterase inhibitor. We analyzed the response of day 16–18 embryonic thymocytes to varying concentrations of Malathion. We hypothesized that greater concentrations of the pesticide would have a greater toxicity in T cells. Flow cytometric analysis was used to determine the level of toxicity and maturation of the embryonic T cells following culture.

130. EFFECTS OF METHOXYCHLOR EXPOSURE ON THE DEVELOPMENT OF CD4 T-CELLS IN C57BL/6 MICE

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T cells, one of many cell types comprising the immune system, protect the body from pathogens and diseases by initiating and orchestrating the adaptive immune response. T cells express one of two main types of co-receptors, CD4 and CD8. Before 1997, researchers were unable to study the development of T cells in the absence of the thymus, a lymphoid organ where T cells develop. However, Cibotti et al. (1997) found specific surface molecules (CD2 & TCR) that were able to signal immature T cells to become mature T cells in the absence of thymic epithelium. The goal of this project was to study the effects of methoxychlor (MXC) on the development of T cells using this *in vitro* model of T cell differentiation. MXC is an organochlorine pesticide adopted for use as a safer alternative to DDT, when DDT was banned. MXC is of particular concern because it mimics estrogens and acts as an endocrine disruptor. Previous studies have investigated the toxicological effects of MXC exposure and have found negative effects on the nervous and reproductive systems. Few studies, however, have been conducted investigating the effects of MXC on the development of the immune system, even though exposure to estrogens has been shown to reduce the number of T cells in the thymus (Barr et al., 1982). In agreement with studies of estrogen, we found that MXC did not appear to induce death of developing T cells (Zoller and Kersh, 2006), but rather to alter the T cell developmental program.

AJV is an undergraduate researcher.

131. COMPUTATIONAL ANALYSIS OF GRAINYHEAD-LIKE EPITHELIAL TRANSACTIVATOR (GET1) REGULATED GENES

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Grainyhead-like epithelial transactivator (Get1/Grhl3) is a conserved mammalian homolog of Grainyhead, which plays an important role in the cuticle development in Drosophila. It has been shown that Get-1 plays a critical role in the terminal differentiation of the skin epidermis and is essential for barrier function in mice. Microarray gene expression analysis of Get-1 knockout mice indicates that it regulates a broad array of epidermal differentiation genes encoding structural proteins, lipid metabolizing enzymes and cell adhesion molecules. In order to identify the direct target genes of Get-1, we looked for potential Get-1 sites conserved in the upstream, downstream and intronic regions of mouse and human genes using the ConSite program. Only those genes that had conserved sites in larger conserved regions were considered for further analysis. We considered only those sites that were also present in significantly conserved regions. We analyzed the top fourty differentially expressed genes from the microarray data. Get-1 binding sites were found in eight upregulated and sixteen downregulated genes, indicating that Get-1 directly regulates some genes involved in epidermal differentiation. The fact that both up and downregulated genes contain Get-1 binding sites suggests that Get-1 can both activate and repress transcription.

132. THE EFFECTS OF SODIUM BUTYRATE ON THE SECRETION OF MATRIX METALLOPROTEINASES BY U87MG BRAIN TUMORS

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Matrix metalloproteinases (MMP) are digestive enzymes that, when expressed and secreted by the cell, break down the extracellular matrix. The secretion of MMPs by cancer cells is associated with the process of metastasis. Studying the types of MMPs secreted by cancer cells can give insight into the initiation of metastasis. In this study, a 24-hour sample of MMPs secreted by untreated U87MG cells or cells treated with 2 mM Sodium Butyrate (NaB) for up to eleven days was collected daily into serum-free media. After centrifugation of the serum-free media, secreted MMPs were collected from supernatant. In preparation for separation of MMPs by gel electrophoresis, non-reducing sample buffer was added to the samples of MMPs collected. The gel electrophoresis was run for 1 hour. The gel was incubated at 40 degrees Celsis in 2.5% triton x-100 for 30 min and 50 mM tris pH 7.8 10 mM $CaCl_2$ for 24-hours to digest the MMPs from the gel. The gel was then stained with 0.5% Coomassie Blue/ 30% Isopropyl/ 10% Acetic Acid and destained with 25 g/500 ml $(NH_4)_2SO_4$, 5% Acetic Acid. When comparing separation of MMPs through gel electrophoresis, the MMPs secreted from cells treated with NaB had an additional enzyme band that was not seen in the protein separation of MMPs secreted from untreated cells. It was determined that treatment of cells with NaB secreted an additional MMP otherwise not seen in untreated cells. (This research was supported by a grant from the Ryckman Endowment Student Research Fund at La Sierra University)

133. EXPERIMENTAL RESTORATION OF THE ROCKY INTERTIDAL BROWN ALGA *SILVETIA COMPRESSA* ON URBAN SOUTHERN CALIFORNIA SHORES

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Coastal communities in urban southern California are being altered by anthropogenic disturbances and climate change. Studies indicate shifts in rocky intertidal macrophytes from large, fleshy, highly productive seaweeds towards a less productive flora dominated by crustose algae and disturbance-tolerant, turf-formers. Of particular concern is the widespread decline of the mid-intertidal alga *Silvetia compressa*, an important canopy-forming seaweed that harbors a diverse assemblage of organisms. Restoration has been successful in the re-establishment of ecologically important species in many terrestrial and estuarine habitats but has rarely been attempted on rocky shores. The goal of this study is to experimentally investigate methods of restoring *Silvetia* on southern California shores and to examine two factors known to significantly affect early post-settlement survivorship in this species: canopy protection and grazer activity. A two-way factorial design is being used with simulated plexi-glass canopy and herbivore exclusion (anti-fouling paint) treatments applied to two "seeding" methodologies: 1) bags containing fertile receptacles and 2) transplantation of juvenile thalli (<2.5 cm diameter). Experiments are being carried out at four study sites, three of which now support no or very little *Silvetia* cover. Preliminary results suggest that simulated canopy and herbivore exclusion treatments enhance survivorship of transplanted *Silvetia* juveniles. However, to date attempts to establish juvenile thalli from transplanted fertile receptacles have been unsuccessful. This study will provide insight into the feasibility of restoring ecologically-important rockweeds in disturbed intertidal habitats, and also will improve understanding of how early life history stages of seaweeds respond to stressors on southern California shores.

134. SPATIAL AND TEMPORAL VARIATION IN $\delta^{13}C$ AND $\delta^{15}N$ VALUES OF MACRO-ALGAE IN SOUTHERN CALIFORNIA WATERS

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Stable isotopes are useful tools for assessing the sources of nutrients to macro-algae and the contributions of macro-algal-derived production to benthic consumers. Despite the increasing use of stable isotopes in analyzing the roles of macro-algae in coastal communities, few $\delta^{13}C$ and $\delta^{15}N$ values are available for southern California seaweeds; additionally, variation among and within species over space and time is not well understood. Herein, we report $\delta^{13}C$ and $\delta^{15}N$ values for seven southern California seaweed species, including representatives from the divisions Chlorophyta, Phaeophyta, and Rhodophyta. Seaweeds were collected from two sites during winter and summer to examine spatial and temporal variation in their isotopic signatures. As expected, mean $\delta^{13}C$ values of the tested macro-algae varied within and among species (−19.1 to −13.4‰), irrespective of the division to which they belonged, and were clearly differentiated from published reports for phytoplankton and other coastal production sources. Macro-algal mean $\delta^{15}N$ values were similarly variable (8.4 to 10.3‰), but were enriched compared to $\delta^{15}N$ values reported for macro-algae inhabiting other temperate waters. Six species showed small, but statistically significant differences in $\delta^{13}C$ and four species in $\delta^{15}N$ values between sites and/or

sampling periods. Macro-algal $\delta^{13}C$ signatures did not show a spatial or temporal trend; in contrast, enriched $\delta^{15}N$ signatures were detected during the winter sampling period for six of seven species regardless of site. More data are needed to improve understanding of spatial and temporal variation in $\delta^{13}C$ and $\delta^{15}N$ signatures of seaweeds in southern California waters.

135. HEAT SHOCK PROTEIN 70 (HSP70) EXPRESSION IN MULTIPLE SCLEROSIS

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Multiple Sclerosis is an autoimmune disease of the central nervous system which results in significant areas of demyelination, caused by the immune system attacking myelin. There are three main neural lineage cell types in the brain: neurons, which process and transmit signals all over the body; astrocytes, which ensure homeostasis and affects neuronal activity in the brain; and oligodendrocytes, which form them myelin-sheaths around nerve cells. Heat shock proteins (Hsp) are essential to the everyday survival of cells because they protect all cellular proteins following stress by binding to and ensuring they retain their shape and activity. Hsp can also work as immune stimulators, taking these cellular proteins to the immune system and causing increased immune responses to these proteins. The purpose of my project is to do a two-colored staining of a neural cell and Hsp70 to see which cells are stressed, and overexpressing Hsp70. Using polyacryalmide gel electrophoresis, we determined the capacity of different primary antibodies specific for GFAP (astrocytes), MAP2 (neurons), OSP (oligodendrocytes) and Hsp70 (Heat Shock Protein 70) to recognize proteins in human brain tissue homogenates. The data also show that using immunofluorescence, I could successfully identify the three different lineages of neural cells in the tissues (neurons, oligodendrocytes, astrocytes). The staining for the Hsp70 however did not provide any significant results, even though the antibody recognized proteins in human brain homogenates. Thus double staining with Hsp70 and neural cell antibodies was not feasible. I will try alternate antibodies specific for Hsp70 in future work.

136. A STUDY OF FECAL INDICATOR BACTERIA IN THE BALLONA WETLANDS AND DEL REY LAGOON, LOS ANGELES, CALIFORNIA

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Wetland areas and beaches adjacent to them are a great concern due to their interaction and the presence of sources of fecal contamination. The purpose of this study is to compare densities of fecal indicator bacteria (FIB) in tidal water flowing in two adjacent aquatic ecosystems, the Ballona Wetlands and Del Rey Lagoon. During four surveys in 2005, each site was sampled during ebb tide flows of spring low tides. Samples were collected inside the Ballona Wetlands and in Del Rey Lagoon. At each site, water quality measurements (temperature, salinity, dissolved oxygen, pH) were made using a YSI 600R Sonde, five replicate samples of water were collected for turbidity (HACH 2100N turbidimeter) and FIB determinations and counts of birds feeding or resting on nearby intertidal mudflats were made. Samples were tested for total *Coliforms* and *E. coli* using the IDEXX defined substrate test kits (Quanti-Tray 2000 test trays, Colilert-18 media). Bacteria were further characterized using the API 20E Identification System for *Enterobacteriaceae*. *E. coli* densities were greater in water flowing from the lagoon compare to the wetlands on three occasions, two of which were significantly different ($p<0.05$). The Del Rey Lagoon was observed to have higher concentrations of water fowl than seen in the main channel of the Ballona Wetlands, so the greater *E. coli* densities in the lagoon may be associated with greater bird densities. Based on the metabolic responses indicated by the API system, the *E. coli* measurements obtained using the IDEXX system may represent a variety of *Enterobacteriaceae* species.

137. GEOGRAPHICAL, TAXONOMICAL, TEMPORAL AND HOST SIZE/AGE COMPARISONS OF INTESTINAL PARASITES IN THREE SPECIES OF SCULPINS

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This study investigates three species of tidepool cottids, *Oligocottus maculosus*, *O. snyderi*, and *Artedius notospilotus* that often serve as definitive hosts for digenic trematodes. Analysis of parasite prevalence and mean intensities between the species showed that infection was neither geographically nor taxonomically selective. Also, in *A. notospilotus* and *O. maculosus* the numbers of parasites increased as the size of the host increased, implicating that both species are infected by parasites throughout its lifetime. *O. snyderi* showed no increase in parasites as the size of host increased, suggesting that it is parasitized only as a juvenile. In comparison with previous MBQ studies, there was no significant change in the mean intensity of *O. snyderi* and *O. maculosus* and in the percentage of parasitized individuals of *O. snyderi.*

138. A TAXONOMIC REVIEW OF LATE CRETACEOUS CIMOLESTIDS

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Cimolestids, late Cretaceous mammals known primarily from western North America, are hypothesized to include the origins of Carnivora as well as other placentals. This relationship is based on their biostratigraphic position, within late Cretaceous and early Paleocene (70–64 mya) sediments, as well as the carnassial-like occlusion of their dentition. Current taxonomic relationships of cimolestids are based almost entirely on tooth morphology, and remain largely unresolved. The last major taxonomic study of cimolestids was done in 1973, and our knowledge of early eutherians and the number of specimens collected has more than doubled since then. The methods utilized for analyzing the phylogenetic relationships between taxa has also advanced dramatically.

Even in recent studies of early eutherians, cimolestids are often referred to as a single taxon, providing little detail as to how the known species are related to one another and to other eutherians. The purpose of this study is to examine the known late Cretaceous cimolestids using modern techniques to study their phylogenetic relationships amongst themselves and to earlier eutherians. One cimolestid in particular, *Procerberus*, is of special interest because of its uncertain relationship to *Cimolestes.* Preliminary morphological analyses suggest that it groups within *Cimolestes*, requiring a taxonomic revision of this clade.

139. PRELIMINARY REVISION OF AGRIOCHOERID OREODONTS OF SOUTHERN CALIFORNIA

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Oreodonts are an extinct endemic group of Tertiary North American cetartiodactyls, whose internal systematic resolution and placement within Cetartiodactyla remain contested. Agriochoerid oreodonts represent the earliest and most morphologically primitive grade of oreodont evolution. Within this grade, there is a poorly-researched evolutionary division between species that lead to later agriochoerids and species that lead to Oreodontidae. As this division occurs sometime in the Uintan or Duchesnean, and there are agriochoerids from southern California from that time, it stands to reason that this evolutionary event could have been partially recorded in Southern California. However, only three publications ever have described or identified any specimens of agriochoerids from southern California, with most workers sorting California specimens into species from the better-studied western interior.

This research attempts to decipher how much of the Californian agriochoerid fossil record consists of species endemic to southern California. Early and middle Uintan deposits from San Diego County include an undescribed species that may also be known from the western interior. The existence of *Protoreodon walshi* of San Diego County and *Protoreodon pacificus* of Ventura County show that some endemism existed in the late Uintan – early Duchesnean. A late Duchesnean or earliest Chadronian locality from Death Valley has yielded the only described material for "*Protoreodon*" *transmontanus* and a single tooth possibly attributable to an undescribed species of *Agriochoerus*. Most of these species appear to be closer to the oreodontid evolutionary lineage, supporting a western interior origin for *Agriochoerus*.

140. PHYLOGENETIC POSITION AND BIOGEOGRAPHICAL IMPLICATIONS OF SOUTHERN CALIFORNIA TORTOISES

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Gopherus is a clade of tortoises that have been restricted to North America throughout their history. Gopher tortoises have been discovered throughout the Cenozoic of Southern California spanning over forty million years. A majority of these species remain undrescribed. The only described species is from the Miocene, *G. mohavetus*, and is known from Barstovian and Clarendonian sediments. The taxonomy and phylogenetic position of this species has been highly contested because of its lack of cranial and appendicular material.

Another gopher tortoise appearing to be closely related to *G. mohavetus* has been found in early Arikareean sediments of San Diego County. The discovery of this tortoise helps fill in a gap in the history of the western *Gopherus*, and adds a western record of the group during a time when the clade was only known to inhabit the Great Plains area.

An undescribed *Gopherus* from late Eocene sediments of San Diego County possibly represents the earliest diverging species of *Gopherus* known. This species is very similar in morphology to the earliest known testudinids known *Hadrianus majusculus*. A few characteristics of the shell and the cranial material distinguish the early diverging *Gopherus* from *H. majuscules*.

The description of these tortoises has added important details to understanding the evolution of the only group of tortoises still inhabiting North America. Collection of additional material and future descriptions of this material will help resolve the relationships of these species within *Gopherus*.

141. LAND MAMMALS FROM THE MIDDLE MIOCENE SHARKTOOTH HILL BONEBED, KERN COUNTY, CALIFORNIA

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The Sharktooth Hill Local Fauna is derived from the Sharktooth Hill Bonebed, which is in the upper part of the marine Round Mountain Silt in Kern County, southern San Joaquin Valley, California. The bonebed is well known for its marine vertebrate fossils, especially sharks and marine mammals, but has also produced a smaller number of significant land mammal fossils. These include the musteloid *Brachypsalis obliquidens*; a primitive true feline cat, *Pseudaelurus*, cf. *P. intrepidus*; the huge amphicyonid or "bear-dog", *Pliocyon medius*; the small borophagine dog *Paratomarctus temerarius*; a larger borophagine *Aelurodon* sp.; the three-toed browsing horses, *Parahippus* sp., and *Hypohippus* sp.; a distinctive grazing horse, "*Merychippus*" *brevidontus*; the tapir *Miotapirus* sp.; the rhinoceroses *Aphelops megalodus* and *Teleoceras medicornutum*; a generalized camel of the subfamily Miolabinae; a camel of the subfamily Aepycamelinae; the deer-like dromomercyid *Bouromeryx americanus*; the protoceratid *Prosynthetoceras* sp.; and a gomphothere *Miomastodon* sp. Together, this assemblage can be correlated to middle Barstovian age assemblages found in the Barstow Formation in the Mojave Desert, the Cache Peak Fauna in the Chanac Formation to the east in the Tehachapi Mountains, the North Coalinga sites on the west side of the San Joaquin Valley near the California Coast Range, and to other Barstovian assemblages elsewhere in North America. This agrees with previous assignments of a middle Miocene age to the Sharktooth Hill Bonebed that have been based on microfossils, mollusks, Sr-isotope dates, and magnetic stratigraphy (Chron C5Br, 15.5 Ma). The fossil land mammal assemblage in the Sharktooth Hill Local Fauna includes only medium- and large-size animals, probably an original bias reflective of a distant source area in the southern Sierra Nevada. The mammal assemblage is not biased among these size groups, however, being comprised predominantly of herding/grazing animals, with slightly less abundant browsing/solitary herbivores, and more rare carnivorans. The assemblage notably includes the one of the earliest North American records of a true feline cat, the last record (by 4 m.y.) of the tapir *Miotapirus*, some of the earliest North American records of the Barstovian-indicative gomphothere *Miomastodon*, and well-preserved examples of the dentally distinctive horse *"Merychippus" brevidontus*, the latter being also found in the North Coalinga Local Fauna and in the Cache Peak Fauna.

142. A NORTHERN OCCURRENCE OF THE COTTON RAT *SIGMODON MEDIUS* WITH *PLIOPHENACOMYS PRIMAEVUS* FROM LATE PLIOCENE AGE DEPOSITS OF LASSEN COUNTY, NORTHEASTERN CALIFORNIA

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Lake deposits in the Madeline Plains have produced *Sigmodon medius* and *Pliophenacomys primaevus* from a fish-bed considered to be late Pliocene (Blancan V) in age. This is the most northern documented occurrence of *Sigmodon* in the western United States and the first known record of *Pliophenacomys* in California. *Sigmodon* prefers warm climates with frost-free winter temperatures. The joint occurrence of *Pliophenacomys* with *Sigmodon* is reported in four Blancan V faunas in Kansas, Nebraska, South Dakota and Arizona. The faunas of the Plains states are between 2 and 3 Ma and occur near the same latitude as the Madeline Plains. These two rodents occur at 111 Ranch in Arizona at 2.5 Ma. Topographic barriers to the east appear prohibitive for a dispersal route for *Sigmodon* whereas it is common in Pliocene faunas of the southwest with a better dispersal route northeast of the Sierra Nevada. The Madeline Plains lake is significantly older than Pleistocene Lake Lahontan and contains a fish fauna with several endemic species intermediate between those represented in the early Pliocene Alturas Formation and Lake Lahontan. The absence of salmonids in the Madeline Plains lake implies no outlet to the Pacific Ocean. Sympatry of these two rodents presents an anomaly that requires either unique climatic conditions, different environmental tolerances for *Pliophenacomys* than its extant descendants, or tectonic conditions that provided an overlap of their geographic ranges. A large lake in this region 2.5 to 2 Ma may have ameliorated the winter temperature and produced frost-free conditions tolerable for *Sigmodon*.

143. A NEW IRVINGTONIAN LAND MAMMAL ASSEMBLAGE FROM THE SAUGUS FORMATION, MOORPARK, VENTURA COUNTY, CALIFORNIA

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The dominantly continental Saugus Formation recently yielded a newly recorded, fossil land mammal assemblage in the William Lyon Homes, Inc., Meridian Hills parcel at Moorpark, Ventura County, California. The Meridian Hills Local Fauna includes *Sylvilagus*?, *Thomomys*, *Perognathus*, *Dipodomys*, *Reithrodontomys*, *Neotoma*, *Pitymys meadensis*, *Mammuthus meridionalis*, *M. columbi*, *Equus occidentalis*?, and *Hemiauchenia macrocephala*. The *M. meridionalis* record, a skeleton ~70% complete, is one of the two most complete specimens known from North America. Its association with *M. columbi* is only one of three associations of these species reported from North America. *M. meridionalis* dispersed from Asia to North America about 1.8 million years ago, and went extinct in North America roughly 300,000 years ago. *P. meadensis* represents another such dispersal and defines the beginning of Irvingtonian II (earlier [but not earliest] part of Irvingtonian North American Land Mammal Age [NALMA]), which ranges from 850,000 to 400,000 years ago. The last record of this species is approximately 252,000 years in age. Associated magnetostratigraphic data indicate that the sediments comprising the fossil-bearing strata at the *P. meadensis*/*M. meridionalis* site were deposited during an geomagnetic interval of reversed polarity. In North America, the only reversed-polarity geomagnetic interval that overlaps the temporal ranges of *P. meadensis* and *M. meridionalis* is the Matuyama Magnetochron, which lasted from 2.58 million to 780,000 years ago. These data suggest that the fossil-bearing strata are 850,000 to 780,000 years (early Pleistocene) in age and assignable to the earlier (but not earliest) part of the Irvingtonian NALMA (Irvingtonian II).

144. REVISED TEMPORAL RESOLUTION OF THE LATE IRVINGTONIAN AGE FAIRMEAD LANDFILL FAUNA, MADERA COUNTY, CALIFORNIA

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The Fairmead Landfill fauna is a diverse assemblage of fossils vertebrates of late Irvingtonian age recovered from deposits of the Turlock Lake Formation. A recent examination of the stratigraphy at the landfill site with special emphasis on the bone concentration, coincident with a review of the geologic literature of the San Joaquin Valley indicates that the age resolution of this assemblage can be significantly

refined providing greater utility of the collection for paleontological interpretation. The fossils occur within the upper portion of, or directly above a brown clay bed located 40 feet below the ground surface. This clay bed has been identified as the Corcoran Clay, a very distinctive greenish-gray silty clay that is found at the surface and subsurface of the San Joaquin Valley covering an estimated 4,000 square miles. The Corcoran Clay is a member of the Turlock Lake Formation and is associated with a volcanic ash equivalent to the Lava Creek B ash with a radiometric date of 600,000 Ka. Directly overlying the Corcoran Clay Member is the Friant Ash Member of the Turlock Lake Formation that contains the Friant tuff radiometrically dated of 600,000+−0.15 Ka. The Friant ash bed has been identified in the deposits overlying the Corcoran Clay bed at the Fairmead Landfill indicating that both the Corcoran Clay and Friant Ash members are represented at the Fairmead Landfill. The Fairmead Landfill Fauna is of late Irvingtonian age and accumulated along the eastern margin of Lake Corcoran 600,000 Ka.

145. NEW RECORDS OF FOSSIL SHARKS AND BONY FISHES FROM THE LATE MIOCENE IMPERIAL GROUP OF THE ANZA BORREGO REGION, SAN DIEGO COUNTY, CALIFORNIA

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Although fossil marine invertebrates of the late Miocene Imperial Group of the Anza Borrego region of southern California are well documented, in contrast, little is known of the fossil fishes. Recent collections by paleontologists and volunteers of the San Diego Natural History Museum and Anza Borrego Desert State Park have yielded new records of sharks and bony fishes from Imperial Group. From the basal Latrania Formation, in addition to an early record of *Carcharocles megalodon* by Hanna (1926), teeth of *Odontaspis* sp., *Isurus* cf. *I. oxyrinchus*, *Myliobatis* sp., Balistidae, cf. *Semicossyphus* sp., and *Sphyraena* sp. were recovered. Based on the presence of fossil corals and sea urchins, the Latrinia Formation was probably deposited in clear marine waters of the ancestral Gulf of California on the western edge of the Salton Trough some 5 to 7 million years ago. In the overlying Mud Hills Member of the Deguynos Formation, recent collecting has turned up a tooth from a gulper shark (family Centrophoridae). Gulper sharks, related to the modern dogfish (genus *Squalus*), are mainly a group of deepwater marine bottom-dwelling species usually found in waters 1000–1500 m in depth. Today, they are not found in the northeast Pacific (this area). The Mud Hills Member clayey sediments chronicle the Colorado River entering the Salton Trough and building its delta some 5 million years ago. From the overlying Yuha Member of the Deguynos Formation, there are records of *Carcharodon* sp., *Odontaspis* sp., *Carcharhinus* sp., and *Myliobatis* sp. and an Istiophorid. Geologists interpret rocks of the Yuha Member to represent a delta front with oyster beds that was deposited some 4 million years ago.

146. A FOSSIL ZIPHIID WHALE (CETACEA: ODONTOCETI) FROM THE LATEST MIOCENE CAPISTRANO FORMATION IN SOUTHERN ORANGE COUNTY, CALIFORNIA

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Beaked whales of the odontocete cetacean family Ziphiidae are known from Early Miocene time to the present day, and from all oceans of the world. Several species are alive today, but they are generally uncommon, and some species are extremely rare. Fossil ziphiids are likewise rare. During a paleontologic mitigation program in San Clemente, Orange County, California, a fossil ziphiid was discovered in the latest Miocene (approx. 6 to 9 million years) Siltstone Member of the Capistrano Formation. The Siltstone Member was deposited in the ancient Capistrano Embayment in relatively deep and calm water. The ziphiid fossil includes the cranium, mandible, teeth, and ear bones. The cranial length was approximately 92 cm, and in life the animal would have been the size of a medium-size living beaked whale. The cranial vertex is not skewed asymmetrically to the left side, and the premaxillae are expanded and elevated at their posterior ends and extend outward over the maxillae, thereby resembling both the living Baird's Beaked Whale, *Berardius bairdii*, of the North Pacific, and Shepherd's Beaked whale, *Tasmacetus shepherdi*, of the South Pacific. It further resembles *T. shepardi* in having rostral teeth, unlike all other living beaked whales, but unlike *T. shepardi* it may have had enlarged mandibular teeth. Its mandibular symphysis is longer than that of most living species of ziphiids. In most of its characters, the new fossil is relatively primitive, and it probably represents an undescribed species.

147. A MAMMOTH AND ASSOCIATED FAUNA FROM NEWPORT BACKBAY 25,000 YEARS BEFORE PRESENT

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Deep excavations at the corner of Jamboree and Michelson in Irvine have revealed at least three depositional layers with well preserved Pleistocene fossils. All represent overbank deposits outside of the river channel in an area that suffered numerous evaporation events. Radiocarbon dating indicates the deeper portions are about 30 thousand years old while the younger portions are about 25 thousand years old. Pollen indicates an arid, treeless expanse populated by members of the sunflower and goosefoot families. Orientation of the long bones indicates radical shifts in direction of river flow between depositional events. Selenite (gypsum) was present as a layer between the two lower deposits and caliche was present as a layer between the two upper layers. Overall, these results indicate flooding events that transported animal carcasses downriver and deposited them adjacent to the river channel. The sediments then dried out causing evaporates to form. Fossils recovered include rodents, turkey vulture, ground sloth, horse, bison and parts of two mammoths including a nearly complete skull with both tusks.

148. VARIATION AND SEXUAL SIZE DIMORPHISM IN PLEISTOCENE GROUND SLOTHS (XENARTHRA)

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According to the paleontological literature, ground sloths (especially megatheres) show unusually high variability compared to other mammals. We evaluated this hypothesis by measuring all the common limb elements of the mylodont *Paramylodon* (=*Glossotherium*) *harlani* from the late Pleistocene Rancho La Brea tar pits in Los Angeles, and the megathere *Nothrotheriops shastensis* from Rancho La Brea and also from late Pleistocene San Josecito Cave, Nuevo Leon, Mexico. We find no evidence of unusually large variability (as measured by coefficient of variation and other statistics) in any postcranial element of either of these taxa. We also evaluated change in size through time in the different aged pit samples from Rancho La Brea, and found no significant size changes in *P. harlani* from 40,000 to 10,000 years ago. This is consistent with the fact that some megatheres (such as *Eremotherium laurillardi*) show clear evidence of sexual size dimorphism, but *P. harlani* skulls exhibit shape, but not size, dimorphism. We conclude that sexual size dimorphism is not as widespread in sloths as once assumed.

149. PALEOENVIRONMENTAL INTERPRETATIONS OF PLEISTOCENE DEPOSITS AT THE PACIFIC CITY PROJECT SITE IN HUNTINGTON BEACH, SOUTHERN CALIFORNIA

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Samples of Pleistocene pond and stream deposits exposed in excavations for the Pacific City Project in Huntington Beach have produced both plant microfossils (pollen and spores) and macrofossils (seeds) which provide information on the depositional environment and both local and regional paleo-vegetation. Also present at this locality are aeolian (dune) sediments. Charcoal-bearing pond deposits near the base of the stratigraphic section have been radiocarbon dated at 40 kybp. The dominant floral elements present are herbs (Compositae/Asteraceae, Chenopodiaceae) and grasses (Poaceae), together making up more

than 60% of the palynoflora. Trees are dominated by oaks and pines, together making up only 3% of the palynoflora. Also represented are willow, alder, cottonwood, walnut, and sycamore, along with a few ferns, cattail, and an abundance of freshwater algal spores. Together with the sedimentary record at this site, this low diversity paleoflora suggests vernal pond vegetation in a coastal dune field near the mouth of the ancestral Santa Ana River. The local vegetation in this environment was dominated by seasonal herbs and perennial dune grasses. The regional vegetation included oak woodlands with occasional pines and junipers. The remaining elements in the paleoflora appear to represent riparian vegetation. The paleoclimate suggested by these samples is cooler and wetter than the modern climate of Southern California, and perhaps more like coastal central California.

150. NESTING SUCCESS OF COSTA'S HUMMINGBIRD IN ARTICHOKE THISTLE INVADED CALIFORNIA GRASSLANDS

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Artichoke thistle (*Cynara cardunculus* L., Asteraceae) is an invasive plant to coastal California that outcompetes native plants in disturbed areas, disrupting grassland habitat and potentially impacting wildlife populations. *C. cardunculus* is a food and nesting resource for hummingbirds. However, preliminary observations indicated that although hummingbird nests constructed on artichoke thistle produce hatchlings, these young rarely fledge due to plant structural failure resulting from the weight of the growing birds. We hypothesized that the overall interaction from the perspective of the hummingbird would be negative due to a failure to produce juveniles in thistle-invaded patches. The success of Costa's hummingbird nests built on *C. cardunculus* within an invaded grassland habitat in southern California was within normal ranges when compared to other researchers' values. This falsifies our hypothesis and suggests that the overall effect of *C. cardunculus* on hummingbird nest success is positive despite 76% nest failure. We also observed that nests built on live *C. cardunculus* were less successful than those on dead thistles. This may be because nests built on live thistle are more likely to collapse. In 2005 nest site selection revealed a slight preference for live thistles as substrate, and most nests failed. However, in 2006 birds preferentially nested on dead thistle, suggesting that learning is involved in selecting appropriate nest sites for Costa's hummingbird. *C. cardunculus* is a novel nesting and feeding resource that is absent in non-invaded grasslands, thus its presence benefits local hummingbird populations and may be a means of habitat expansion.

151. POPULATION STATUS AND TRENDS OF THE CALIFORNIA LEASTTERN, *STERNULA ANTILLARUM BROWNI*, AND THE WESTERN SNOWY PLOVER, *CHARADRIUS ALEXANDRINUS NIVOSUS*

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The least tern was listed as endangered with extinction in 1970 and the western snowy plover was listed as threatened in 1993. Both species rely on coastal beach strand or similar habitats for nesting. Dense human occupancy and activities along the coast pose major constraints to recovery of these two listed birds. Besides human disturbance of potential nesting areas, predators subsidized by human activities are abundant. The least tern population trend has been greatly increasing during the last several years. Creation and protection of man-made nesting areas and predator management have greatly benefited the least tern. The snowy plover population is currently much less numerous than the least tern and the trend has been erratic and, at best, slightly increasing. Both species sometimes share nesting areas and benefit from predator management and some nest site protection efforts. Major differences in nesting behavior and chick-rearing, make simultaneous management efforts for both species very difficult but not impossible. To date, creation of man-made nesting areas for snowy plover are few but have appeared to be successful when accompanied by predator management. The recent nesting occurrences of the rare gull-billed tern, *Gelochilodon nilotica vanrossemi*, at San Diego Bay has created another predator management quandary due to the predation on least tern and snowy plover chicks by gull-billed tern adults feeding their chicks.

152. DISTRIBUTION AND HABITAT ANALYSIS OF THE WESTERN BURROWING OWL IN AN URBANIZING ENVIRONMENT

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The western burrowing owl is a small, ground dwelling owl. It is found across western North America and into Central and South America. In general it is a habitat generalist, being found on grasslands, desert scrub, golf courses and a myriad of other sparsely vegetated habitats. It is, however, a specialist in regards to its nesting habitats as it is dependent on burrows excavated by ground burrowing animals such as ground squirrels, prairie dogs, badgers, tortoises and the like. It has been extirpated from portions of its historic range, and is declining in most other portions of its range. Its conservation has become a "hot" topic among California policy makers, conservationists and raptor biologists. The development of a habitat model for the express purpose of guiding conservation may be important. Using Western Riverside County as the study area, surveys were done over a four year period to locate owls. Using ArcGIS and a suite of habitat variables, a habitat suitability index was generated. This habitat model, or niche model, may provide some insight into the appropriate areas to concentrate on for conservation.

153. 2006 CACTUS WREN STUDY, NATURE RESERVE OF ORANGE COUNTY

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The 1993 Laguna Beach Fire burned ~75% of the coastal reserve of the Nature Reserve of Orange County (NROC). Annual Cactus Wrens sampling indicated a 58% decline, from 132 (±93) in 1999 to 55 (±40) in 2004, vs. a 26% estimated decline in the NROC's central reserve In 2006, during two rounds of surveys across the coastal reserve, I mapped and classified all cactus-containing habitats within 20 management areas and detected 65 wren territories. A site occupancy model gives a 2006 estimate of 71.4 (±6) territories in the coastal reserve (including non-reserve areas). Out of 2323 acres of cactus scrub mapped in 2006, 1336 acres (58%) appeared to be insufficiently developed for occupancy (mainly due to fire). Only 187 acres were occupied, whereas the model estimates occupancy of 1473 acres in 1992, an 87% decline. Out of eight management areas with at least 8 territories in 1992, only two areas in Irvine—Sand Canyon and Turtle Rock—showed no significant declines 1992–2006. Significant declines in two unburned management areas—Sycamore Hills and Aliso & Woods—may reflect differences in biological productivity (areas near grasslands being more stable), edge effects (but some edge areas have stable wren populations), and dispersal (dispersing wrens may preferentially settle in habitat near robust wren populations). Given the wren's small population in the coastal reserve, the slow recovery of burned cactus, and significant declines in some unburned areas, this population warrants further study and development of a management program that aims toward short-term population stabilization.

154. *CHARADRIUS ALEXANDRINUS* POPULATION SURVEYS AT OWENS DRY LAKE, INYO COUNTY CALIFORNIA PRE- AND POST SHALLOW FLOOD DUST CONTROL IMPLEMENTATION

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In a historic Memorandum of Agreement between the U.S EPA and the Los Angeles Department of Water and Power (LADWP), LADWP agreed to control dust emissions on the Owens dry lake bed to meet PM^{10} air quality standards. Ten years and hundreds of million dollars later the once dry lakebed has over 10 square miles of shallow flooded surface that not only suppresses dust, but supports abundant brine fly populations (*Ephydra hians*) and a burgeoning shorebird population. The Western snowy plover (*charadrius alexandrinus nivosus*) has historically nested at Owens Dry Lake between March and August each year and the baseline adult population was estimated at 272. With the construction of water-based dust control measures this population has steadily increased reaching a high of 658 adults in 2004 and 602 adults in 2006. Nesting success has increased, as has the number of clutches each season per adult female. Pre-project the plover were dependent on 3 or 4 natural seeps that outflow onto the dry lake bed and dry as the summer progresses limiting the useable nesting area to roughly ½ mile around each seep and focusing predation in these areas. Shallow flood dust control sprinklers provide seep like conditions over 10 square miles of the dry lake bed on a consistent basis through most of the breading season resulting in a reliable source of food and water within and adjacent to the dust control areas that greatly expands potential nesting area and reduces predation.

155. THE SANTA ANA RIVER FROM CREST TO CREST – A PHOTO EXPLORATION

Patrick Michell.

Abstract not received at time of publication.

156. LEAST BELL'S VIREOS OF THE SANTA ANA RIVER – RECOVERY IN PROGRESS

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The Least Bell's Vireo, *Vireo belli pusillus*, is an endangered bird of riparian habitats in California and Mexico. Its decline is due to habitat loss and nest parasitism by Brown-headed Cowbirds, *Molothrus ater*. A low count of 19 pairs was documented in Prado Basin in 1986 by U.S. Fish & Wildlife biologists. A management program consisting of habitat restoration and cowbird trapping was initiated at Prado Basin in a cooperative effort among the Orange County Water District, the Army Corps of Engineers, and the U.S. Fish & Wildlife Service. The Santa Ana Watershed Association (SAWA), a non-profit organization dedicated to the restoration and enhancement of natural resources along the Santa Ana River, joined the effort in 1997. SAWA has enacted major habitat restoration for the vireo with the removal of approximately 3,000 acres of giant reed, *Arundo donax*, and associated invasive species from the watershed since 1997. Over 70,000 Brown-headed Cowbirds have been removed from the Prado Basin since 1986 and over 10,000 cowbirds have been removed outside the Prado Basin by SAWA since 2000. The Least Bell's Vireo population in the watershed has increased from 19 territories in 1986 to 991 in 2005. Parasitism rates, which in the early 1980s were as high as 100%, significantly declined in the Prado Basin after the initiation of cowbird trapping (Chi-square 2×2 contingency table; statistic = 20.3 [Yates correction factor applied]; $p < 0.00001$). Annual data collected on the vireos' reproductive success, parasitism rates, depredation rates and nest site characteristics are briefly presented.

157. RESTORATION OF THE RIPARIAN FORESTS OF THE SANTA ANA RIVER. THE SANTA ANA RIVER WATERSHED PROGRAM, 1997–2007

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Encompassing 3,200 square miles, the Santa Ana River Watershed is the largest drainage in coastal southern California. The river originates in the San Bernardino and San Gabriel Mountains and flows over 100 miles through San Bernardino, Riverside, Los Angeles and Orange Counties to the Pacific Ocean. The Santa Ana River Watershed Program was formed in 1997 to restore the natural functions of the river through control of destructive, invasive species, restoration of habitat, and wildlife management emphasizing rare and endangered species. The Watershed Program is a collaborative attempt of the Santa Ana Watershed Association to focus public and private funding on prioritized natural resources issues. The component agencies include four Resource Conservation Districts on the river, Orange County Water District, and the U.S. Army Corps of Engineers; partners include the U.S. Fish and Wildlife Service, California Department of Fish and Game, Regional Water Quality Control Board, Santa Ana Watershed Project Authority, Riverside County Parks and Open Space District, the counties, cities, and many others. Approximately 3,000 acres of giant reed, *Arundo donax* have been removed at a cost of about $14,000,000 and native riparian habitat has expanded into at least 50% of the reclaimed floodplain.

158. HERPETOLOGICAL SURVEYS OF THE SANTA ANA WATERSHED

M. Aimar, R. Zembal, J. Bradley, S. Hoffman, B. Nash, T. Wiater, T. Reeser, A. Beckman, and J. Coumoutso. Santa Ana Watershed Association, 25864-K Business Center Dr., Redlands, CA 92374

The Santa Ana Watershed Association (SAWA), a non-profit organization dedicated to the restoration and enhancement of natural resources along the Santa Ana River, is conducting herpetological surveys in support of restoration activities throughout the Santa Ana Watershed. Surveys are conducted following the pit-fall trapping design by Stokes, et al 2001. Since 2003, 5 sites have been inventoried including Santiago Canyon, Temescal Canyon, San Timoteo Canyon (2 locations), and the former marine base at El Toro, for a period of one year each. A total of 20 reptile and 5 amphibian species have been captured for a total 25 herpetofauna species. Common species found at all locations include western toad (*Bufo boreas*), side-blotched lizard (*Uta stansburiana*), western fence lizard (*Sceloporus occidentalis*) and southern alligator lizard (*Elgaria multicarinatus*). California Species of Special Concern found at one or more locations include western spadefoot toad (*Spea hammondii*), orange-throated whiptail (*Aspidoscelis hyperythra*), coast horned lizard (*Phrynosoma coronatum*), coast patch-nosed snake (*Salvadora hexalepis*) and red diamond rattlesnake (*Crotalus ruber*). Incidental captures of up to 7 small mammal species were noted. Capture and incidental sighting data, as well as vegetation characteristics and soil types are presented for each sampling site.

159. HISTORICAL CHANGES IN THE FRESHWATER FISH FAUNA OF THE SANTA ANA RIVER

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The Santa Ana River watershed covers an area of about 2,650 square miles. Historically the watershed included approximately 3,900 miles of streams, both perennial and intermittent, that could support aquatic resources and only one natural freshwater lake of significant size, Lake Elsinore. Over the past 200 years, much of the landscape and resources of the Santa Ana River watershed have been changed by settlement and development. About 32 percent of the land use is residential, commercial, or industrial. Agricultural land, once accounting for virtually all of the land use in the watershed in the days of the ranchos, now accounts for about 10 percent. Instead of a scattered population of indigenous peoples, the watershed now supports more than 5 million people. It is not surprising that the fish fauna of the Santa Ana River watershed has changed dramatically since the first significant diversions of water were made by the Spanish in 1818. Historically, the Santa Ana River contained a limited fish fauna of only eight species of native freshwater fish. Currently, four of the eight fish species are believed to be extirpated from the watershed. The four native non-estuarine fish that remain are the arroyo chub, Santa Ana speckled dace, Santa Ana sucker, and the threespine stickleback. All of these remaining fishes have limited distributions and may be subject to extirpation. The Santa Ana sucker is listed by the federal government as a "threatened" species pursuant to the ESA. In contrast at least 33 fishes have been introduced into the Santa Ana River watershed, are currently present, and new species can be expected to be found at any time due to inter-basin water transfers, dispersal of species introduced by ships emptying their ballast water, bait bucket introductions, and hobbyists disposing of unwanted fishes. Government agencies introduced most of these to serve as a food resource, for sport fishing, as forage for sport fishes, or for mosquito and aquatic plant control.

160. BIOLOGIC, HISTORIC AND SOCIAL CONSIDERATIONS FOR INTRODUCTIONS OF SANTA ANA SUCKER (*CATOSTOMUS SANTAANAE*) AND SANTA ANA SPECKLED DACE (*RHINICHTHYS OSCULUS* SSP.) INTO THE UPPER SANTA ANA RIVER

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The upper Santa Ana River, between the Seven Oaks Dam and it's confluence with Bear Creek, has recently become an area of interest for multiple parties concerned with the survival and recovery of Santa Ana sucker (sucker) and Santa Ana speckled dace (dace). Although it is unclear if either of these species

ever inhabited this section of the river, recent developments in water use and diversion authorizations have "recreated" a perennial stretch of the river that had previously been subject to intermittent flows. Assessment of current fish and macroinvertebrate assemblages indicate that this reach of the river does currently provide suitable habitat for sucker and dace. Both of these species are experiencing severe habitat and distribution declines and multiple agencies and organizations are taking an interest in finding suitable habitats where they can be introduced as a part of a conservation or recovery effort. In this presentation we provide a review of some of the history of this stretch of the river along with descriptions of some social, political and biological issues that have shaped the past and present condition of the river. Discussion of a potential future condition as a recovery/refuge habitat for sucker and dace will be presented in the context of known conflicts with nonnative species, ongoing recreational and consumptive uses, and proposed water developments

161. FLORA OF THE SANTA ANA RIVER

Oscar F. Clarke and Greg Ballmer.

The Santa Ana River is central to the regional ecology of the greater Los Angeles-Inland Empire area. Its main watercourse and tributaries drain about 2400 sq. miles, linking the Santa Ana, San Bernardino, San Gabriel, and San Jacinto Ranges, plus Chino Hills, with the sea shore and provide the most extensive network of natural wildlife habit linkages in Cis-montane Southern California. Diverse habitats within the watershed also support a proportionately great diversity of plant species; the lowland plants (below 3000 ft elevation) are the primary focus of the recently published **Flora of the Santa Ana River and Environs, with References to World Botany**, by Oscar. Clarke, Danielle Svehla, Greg Ballmer, and Arlee Montalvo. The text deals with 1365 taxa, of which 496 are exotic. About 900 of the more frequently encountered and/or biologically most significant species are illustrated in some detail. The text also includes diverse information on plant origins, ecology, anthropogenic uses, and relationships to other plants. This presentation will focus on the production history of the book, including the techniques and the philosophy behind its unique construction

162. DEMYSTIFYING A RARE AND SECRETIVE SPECIES OF THE SANTA ANA RIVER, THE SOUTH COAST GARTERSNAKE (*THAMNOPHIS SIRTALIS* SSP.)

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Recently the boundaries separating the three currently recognized subspecies of the common gartersnake (*Thamnophis sirtalis infernalis*, *T. s. fitchi*, and *T. s. tetrataenia*) within California have been reinterpreted (Rossman et al. 1996 vs. Stebbins 1985, 2003). Additionally, the distribution patterns of these subspecific units, historically defined by fairly uniform color patterns, are not supported by molecular evidence (Janzen et al. 2002). These developments are not surprising considering the genus *Thamnophis* has a notoriously confusing taxonomic history. First reported in 1994, Jennings & Hayes suggested that the population of *T. s. infernalis* (termed, South Coast gartersnake), occurring south of the Transverse Ranges and west of the Peninsular Ranges, was possibly a unique and undescribed form. The South Coast gartersnake (*T. sirtalis* ssp.) has highly localized populations in Ventura, Los Angeles, San Bernardino, Riverside, Orange, and San Diego, Counties. However, based on our findings, this species is possibly extinct from Los Angeles and San Bernardino, Counties. Currently the South Coast gartersnake is a CDFG Species of Special Concern.

In an attempt to better understand the life history, ecology, distribution, and taxonomic status of the South Coast gartersnake (*T. sirtalis* ssp.) we have begun conducting several studies to resolve these uncertainties. In this presentation, our first in a series, we provide an updated distribution map that includes many previously unreported records, describe essential habitat features, and discuss landscape changes that have enhanced populations at some locations and likely eliminated populations elsewhere. The greatest number of records for the South Coast gartersnake are from the Santa Ana River and the greatest concentration of the records is within the Prado Basin. These records present a unique opportunity for studying this rare and secretive species on a finer scale not previously possible.

163. CHANGES IN HABITAT AFFECT THE POPULATION DYNAMICS OF THE FEDERALLY THREATENED SANTA ANA SUCKER, *CATOSTOMUS SANTAANAE*, IN THE SANTA ANA RIVER

Andrew Thompson[1], Jonathan Baskin[2,3], and Tom Haglund[2,3]. [1]U.S. Fish and Wildlife Service, 6010 Hidden Valley Road, Carlsbad, CA 92011; [2]Biological Sciences Department, California State Polytechnic University Pomona, 3801 West Temple Avenue, Pomona, CA 91768; [3]San Marino Environmental Associates, 560 South Greenwood Ave., San Marino, CA 91108

To elucidate forces that influence *Catostomus santaanae* population dynamics in the Santa Ana River, the Santa Ana Sucker Conservation Team, which is comprised of scientists, regulators and stakeholders, conducted several observational and experimental studies. First, a microhabitat selectivity study revealed that adult and juvenile fish tend to select habitats with cobble/gravel substrate and avoid sand-dominated environments. Next, annual censuses and habitat assessments demonstrated that abundance decreased in two downstream sites and increased at one upstream site between 2003 and 2006. The decreases were likely caused by a temporal shift in substrate composition from cobble/gravel to sand. Next, a 2006 survey of substrate along a 30-km stretch of the river revealed that cobble/gravel is mostly confined to the upstream 8 km whereas downstream locations are mostly sand. Comparison of the 2006 habitat survey with data from 2000 indicated that cobble/gravel declined significantly among years. The Team currently is conducting experiments seeking to augment cobble/gravel habitat through the placement of gabion structures into the river. Gabions have the potential to expose cobble/gravel that may be covered by sand by increasing scour along gabion edges. Preliminary results indicate that gabion addition successfully uncovered buried cobble/gravel habitat. Overall results stress the importance of cobble/gravel habitat to *C. santaanae* persistence and suggest that large-scale sedimentation may be degrading *C. santaanae* habitat. In light of this finding, the Team is striving to develop a management strategy that simultaneously alleviates this threat while allowing for a myriad of ongoing, vital anthropogenic activities in the Santa Ana River.

164. AQUATIC INSECTS OF THE SANTA ANA RIVER: COMMUNITY STRUCTURE AND BIOASSESSMENT ON ALTITUDINAL GRADIENT

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The aquatic insects of the Santa Ana River were sampled biennially between 2002 and 2006 in April at 2–3 locations between 1680 m ASL and 238 m ASL as part of a bioassessment training exercise. Taxon richness declined directly with elevation. The number of aquatic insect genera collected in samples at the high elevation site was 3–5 times that collected in samples at the low elevation site. The mean biotic index based on genus- to family-level identification was approximately 5–6 at Rubidoux, 4.6 at Highland and 3.5–2.5 at Seven Oaks indicative of fair to fairly poor water quality at the low elevation site and excellent water quality near the headwaters. Water column chlorophyll biomass, bacteria abundance, pH, specific conductance and discharge at Rubidoux were comparatively higher than at Seven Oaks. The relative abundance of aquatic insect functional feeding groups conformed well to the river continuum concept that predicts changes in faunal composition with stream order, energy inputs and ecosystem function. Collectors were only about 53% of specimens in samples taken near Seven Oaks. Filterers accounted for 14%, grazers accounted for 18%, and predators and shredders comprised the remaining 15% of specimens in samples from the high altitude site. Collectors were approximately 90% of the insects collected from the comparatively sandy substrates at Rubidoux. The most abundant benthic insects in the lower Santa Ana River were moderately pollution-tolerant generalist feeders and rapid colonizers such as Simuliidae (black flies), Chironomidae (midges), and Baetidae (mayflies) that can tolerate the interannual differences in scouring.

165. *PSEUDO-NITZSCHIA* BLOOM DYNAMICS IN COASTAL WATERS NEAR LOS ANGELES AND CONFIRMED CASES OF DOMOIC ACID POISONING IN MARINE MAMMALS

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The presence of toxic algal species that belong to the genus *Pseudo-nitzschia* in coastal waters along the Los Angeles and Orange County shorelines has been documented repeatedly in recent years. Commensurate with toxic blooms of *Pseudo-nitzschia*, hundreds of marine mammals (pinnipeds and cetaceans) have been received in Mammal Care Centers in Southern California. The animals fall sick and frequently die after consuming domoic acid-contaminated prey such as planktivorous fish which ingest the algae. The time lag between increases of domoic acid (DA) concentrations in the water, the contamination of potential prey (eg, sardines and anchovies) and consecutively the contamination of top predators such as Californian sea lions is not well documented. Transfer efficiencies and residence times of the toxin within the food web are essentially unknown. Comprehensive monitoring of bloom dynamics (eg, cell abundances and DA concentrations) by the University of Southern California, in conjunction with DA-testing of stranded animals made possible by the Mammal Care Centers, is beginning to provide insight into the relationship between toxic blooms and animal poisonings within the LA coastal region. One of the goals of this work is the use of information on the severity and duration of toxic blooms to aid mammal rescue and rehabilitation efforts.

166. DOMOIC ACID POISONING OF CALIFORNIA SEA LIONS IN SOUTHERN CALIFORNIA WATERS: CLINICAL AND PATHOLOGICAL FINDINGS

R.H. Evans. Pacific Marine Mammal Center, 20612 Laguna Canyon Road, Laguna Beach, CA 92651

For the past 8–10 years, poisoning by the …toxin Domoic Acid (DA) has been recognized as a very significant category of mortality for California Sea Lions (*Zalophus californianus*) in southern California waters. This short review will illustrate the clinical and pathological findings noted in DA intoxication in these animals. Clinical and pathological findings are attributed to: 1) anorexia with resultant cachexia or dehydration, malnutrition and subsequent decline in body condition and 2) neurologic dysfunctions from specific biochemical pathologies of the central and peripheral nervous systems, which are the result of direct competitive action with neuronal neurotransmitters at their receptors. Clinical signs include varying degrees of somulence, paresis, paralysis, unusual locomotion, blindness and hearing dysfunctions, which are frequently upstaged by varying types and stages of seizure activity, often as *status epilepticus* or continous epileptiform convulsions. Pathologic microscopic lesions are generally noted in the central and peripheral nervous systems as well as the eye and heart. In the central nervous system, the *Hippocampus* is targeted with extensive degeneration and loss of large neurons within CA areas as well as the *Dentate Gyrus.*

167. LEVELS OF PCBS AND DDT IN PINNIPEDS OF THE SOUTHERN CALIFORNIA BIGHT

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Coastal regions adjacent to highly industrialized areas, such as the Southern California Bight (SCB), often have sediment repositories of chlorinated pesticides, such as dichlorodiphenyltrichloroethane (DDT), and polychlorinated biphenyls (PCBs) that can chronically expose organisms to these pollutants long after the use of these materials has ceased. One of the most susceptible groups of marine organisms is the pinnipeds because of their high trophic standing and high lipid content. PCBs and chlorinated pesticides were analyzed in the blubber of 146 pinnipeds (92 California sea lions *Zalophus californianus*; 43 northern elephant seals *Mirounga angustirostris*; and 11 harbor seals *Phoca vitulina*) acquired from stranded animals that died at local marine mammal centers in the southern California region between 1994–2006. DDTs were the most predominant contaminants, followed by PCBs, chlordanes, and BHCs. Northern elephant seals had significantly lower concentrations of tPCB and tDDT than California sea lions and harbor seals. Adult female California sea lions typically had significantly lower concentrations of tDDTs and tPCBs than the pup, yearling, and adult male age and gender classes. There was a significant decline in both tDDTs and tPCBs over time occurring in California sea lions, but not for northern elephant seals. Current concentrations of tDDTs and tPCBs in California sea lions and harbor seals are among the highest values reported worldwide for marine mammals in recent years and exceed those reported to cause adverse health effects in harbor seals.

168. A PRELIMINARY EXAMINATION OF MORTALITY PATTERNS IN STRANDED SAN DIEGO COUNTY CETACEANS, 1978–2006

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Between the years 1978 and 2006, 375 cetaceans stranded (dead and alive) along San Diego Co. coastline, averaging 13 (range: 5–23) per year. Post-mortem examinations were conducted on a total of 81 cetaceans, representing 3 species of mysticetes and 9 species of odontocetes. Overall, mortalities were attributed to the following categories: trauma (23.5%), undetermined (21.0%), other (13.6%), encephalopathy (8.6%), pneumonia (7.4%), sepsis (6.2%), stillbirth (4.9%), domoic acid toxicosis (4.9%), neoplasia (2.5%), coccidiomycosis (2.5%), hepatitis (2.5%), and pulmonary edema (2.5%). Single cases of the following conditions contributed to the "other" category: abdominal wall perforation, brucellosis, congestive heart failure, emaciation, erysipelas, lymphadenitis and peritonitis, nasal sac trematode aberrant migration, neonatal status, nephritis, ankylosing spondylitis, and vaginal necrosis. Peaks in bottlenose dolphin (*Tursiops truncatus*), short-beaked common dolphin (*Delphinus delphis*), and long-beaked common dolphin (*Delphinus capensis*) strandings occurred during the years 1980, 1989/1995/2003–2005, and 2004/2006, respectively. Although 66.7% of *T. truncatus* strandings were necropsied in 1980, no clear trend in mortality diagnoses was apparent; this suggests that observed maladies may have been secondary to infectious or biotoxic agents unknown to researchers at that time. *D. delphis* strandings from 2003 and 2005 were partially attributed to domoic acid toxicosis and encephalopathy while the peak in *D. capensis* in 2004 was largely due to trauma, primarily from fishery entanglement. Stillbirths and domoic acid toxicosis were only observed in bottlenose dolphins during the early 1980s and common dolphins (*Delphinus* sp.) after 2002, respectively. The limitations of diagnostic evaluations and rapidly developing new methods necessitate thorough post-mortem examinations and proper banking of samples for future evaluations.

169. *STAPHYLOCOCCUS AUREUS* NEPHRITIS IN A CALIFORNIA SEA LION (*ZALOPHUS CALIFORNIANUS*)

V. Favel. Pacific Marine Mammal Center, 20612 Laguna Canyon Road, Laguna Beach, CA 92651

This presentation will be an illustrative documentation of a case *Staphylococcus aureus* severe, diffuse, bilateral nephritis in the California Sea Lion (*Zalophus californianus*). Gross, cytological and histological lesions will be shown in detail and the relevance of semi-isolated Renicular lesions will be discussed in terms of sea lion kidney anatomy. In conclusion, a discussion of the significance of *Staphylococcus aureus* as a pathogen in the California Sea Lion will be undertaken.

170. CONSIDERATIONS IN MARINE MAMMAL BRUCELLA INFECTIONS

J.A. St. Ledger. SeaWorld, San Diego, CA 92109

Infections with the marine mammal strains of *Brucella sp.* are identified with increasing frequency. Improved diagnostics and an expanded understanding of the behavior of the pathogens will likely result in increasing identification of the infection. Recent studies on European isolates identify 3 distinct species of *Brucella sp.* in marine mammals. The condition in cetaceans is associated with a non-suppurative encephalitis, steatitis, endometritis, placentitis, and vaginitis. Clinical conditions can include abortion, still birth, and obstructive hydrocephalus. Infections in pinnipeds can be non-clinical. Based on comparative pathology, other potential conditions associated with these infections include arthritis, diskospondylitis, and orchitis. Diagnosis of these infections remains an art. Bacterial culture of the two cetacean *Brucella sp.* can be performed on blood agar in aerobic conditions at 37 deg. Pinniped organisms require CO_2 for culture. All marine mammal isolates are slow growers and a manimum 21 days of incubation are

recommended. Overgrowth of secondary bacteria is a common culture complication. Immunohistochemistry on suspect lesions may prove unrewarding. Polymerase chain reaction (PCR) is an effective method for identifying bacteria when culture is difficult or impossible. Because bacteria can be isolated without clinical impact or pathologic changes, positive result must be evaluated in light of clinical history and clinical and anatomic pathology. Increased screening for this infection, identification of history and lesions, and further classification of isolates is necessary to better understand the impact of *Brucella sp.* infections in marine mammals. Zoonotic disease precautions should be considered with any marine mammal *Brucella sp.*

171. TOPICAL TREATMENT OF A SHARK BITE IN A CALIFORNIA SEA LION (*ZALOPHUS CALIFORNIANUS*) WITH UNPASTEURIZED HONEY

L. Palmer. The Marine Mammal Care Center Fort MacArthur, San Pedro, CA 90731

In this case report commercially available, unpasteurized honey was utilized as a wond dressing for a yearling, female, California sea lion (*Zalophus californianus*) that had sustained injuries consistent with a shark bite. The animal was admitted with extensive contaminated wounds. In this case, unpasteurized honey effectively debrided necrotic tissue eliminating the need form standard surgical debridement. Bandages were changed every 48 hours and tissue repair and healing were rapid facilitating early return to a pool and eventually to release. A few of the reported therapeutic properties of honey include antibacterial, anti-inflammatory, and tissue debriding properties that are a result of low pH, production of low levels of hydrogen peroxide, high osmolality and stimulation of leukocyte activity. No known adverse effects were noted from the use of honey as a wound dressing in this case.

172. TIDAL DYNAMICS OF FECAL INDICATOR BACTERIA (FIB) IN THE BALLONA WETLANDS, LOS ANGELES COUNTY, CALIFORNIA

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Densities of fecal indicator bacteria (FIB), represented by total coliforms, *E. coli*, and enterococci, were measured in a tidal channel of the Ballona Wetlands (Los Angeles County) to determine fluxes over varying tidal cycles, ultimately addressing the question whether or not the wetlands act as a sink or source of these bacteria. Densities of FIB along with environmental parameters were measured at a single site every 1.5-hrs over a 12-hr period. Four events representing spring to neap tidal conditions were sampled on June 6, 13 and 19, 2006, and on March 2, 2007. Parameters measured every 1.5-hrs included current flows, replicate surface water samples ($n=3$) for FIB and turbidity (NTU). Measurements of depth (ft), oxygen (mg/L), temperature (C°), and pH were taken every 15-min using YSI 6600 continuous recording sonde. Tidal flows ranged from 1.13 m^3/sec during flood and ebb flows to nearly still conditions. Bacterial concentrations (MPN/100 ml) of all FIB groups tended to be greatest during flood flows, especially during morning hours, diminishing throughout the day. Peak bacterial densities averaged 24,192 MPN/100 ml for total coliforms, 208 for *E. coli*, and 3,889 for enterococci. Bacterial flow rates (MPN/sec) tracked water flow rates (m^3/sec) with the greatest bacterial flows of 10^8 MPN/sec. Overall, FIB densities tended to diminish throughout the day even during flood conditions, suggesting that UV light might be a reducing factor. This hypothesis will be tested during the summer of 2007 when FIB sampling will be performed over a 24-hr period coupled with measurements of light intensity.

173. PRELIMINARY ETHNOBOTANICAL INVESTIGATION ON CURRENT USE OF *HYDROCOTYLE RANUNCULOIDES L.F.* IN IXTLAHUCA AND SAN MATEO, TEXCALYACAC, MEXICO

C.J. Cortez and S.A. Banack. Department of Biological Science, California State University, Fullerton, 800 N. State College Blvd., Fullerton, CA 92834

Hydrocotyle ranunculoides L.f. (Apiaceae,), known as "quelites san reje" in Ixtlahuaca and "berro redondo" in San Mateo, Texcalyacac, Mexico, are small aquatic plants found in the wetlands that are prominent in the Valley of Mexico of Mexico State. Ixtlahuaca and San Mateo, Texcalyacac are both located in the Valley of Mexico and are the ancestral home to the indigenous Otomi, Matlatzinca, Mazahuaz, and the Mexica groups. Since the 16th century *H. ranunculoides*, known by the Mexica as "amamalacotl" meaning swirl of wind in Nahuatl, was used as a condiment and to treat minor illnesses. Currently documentation in Mexico on the current knowledge and use of this plant is limited. This study investigates the current use and ethnobotanical knowledge of *H. ranunculoides* in the towns of Ixtlahuaca and San Mateo, Texcalyacac Mexico. This floating plant is harvested form the local wetlands, rinsed, cleaned, and sold fresh. Only specific locations sell *H. ranunculoides* and a decrease in its use has been reported by local people, possibly due their understanding of unsanitary water systems where this plant is harvested. The overexploitation of groundwater resources from this valley is also a threat to the loss of the wetlands and potentially the valuable cultural knowledge of harvesting emergent aquatic plants including *H. ranunculoides*.

174. THE USE OF BEDSIDE ULTRASOUND TO DETECT FREE FLUID IN TRAUMA PATIENTS

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The Focused Assessment Sonogram in Trauma (FAST) in the evaluation of blunt abdominal trauma is generally accepted as the screening modality of choice in adult populations to evaluate for free fluid (FF). However, there are few studies demonstrating its accuracy in the pediatric population, which is what was assessed in this study. This prospective observational study included a consecutive sample of patients aged 0–17 years, suffering blunt abdominal trauma requiring trauma activation that received either CT scans or underwent laparotomy, at a tertiary care Level I Trauma Center University Hospital. After obtaining assent/consent, the senior emergency medicine resident performed and interpreted the FAST at bedside. Using CT scans as the criterion reference, the FAST results were compared to those of CT using descriptive statistics setting the Confidence Interval at 95%. Of the 118 total participants, none were excluded after initial inclusion. Nine percent had a positive FAST showing FF in the abdominal/pelvic cavity. Of those, 100% had a subsequent positive CT scan. Five subjects went to the operating room within 24 hours of evaluation. Of those, three had a positive FAST, demonstrating the sensitivity of FAST in detecting clinically-significant levels of FF is 60%. Overall, the sensitivity of the FAST to illustrate any amount of FF in the abdominal/pelvic cavity is 40%, with a specificity of 99%, positive predictive value of 89%, and likelihood ratio of 39.2. The results indicate pediatric FAST is very specific, but less sensitive than that reported in the adult literature for all degrees of FF.

175. ARMORED MIXED-SOFT SEDIMENTS -A DISTINCTIVELY DIFFERENT SEDIMENT PARADIGM?

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Based on our studies from 1989 through 1996 evaluating effects of treatment of beaches oiled by the *Exxon Valdez* oil spill in Prince William Sound (PWS), we hypothesized that bivalve assemblages and sediments on treated beaches were severely injured by high-pressure washing. In 2002, we conducted a follow-up study to determine if these effects persisted and were widespread in PWS and to gain insight into clam recovery rates. During this study, we found that sedimentary components and the biota in the armored mixed-soft sediments in PWS do not respond in accordance with the conventional paradigms described for homogeneous sediments. Relationships between median grain size, fines, organics, and biodiversity in PWS sediments diverge substantially from those commonly used to describe traditionally recognized homogeneous sediments. Although armored sediments apparently are widely distributed, paradigms describing the relationships among grain size, fines, organics, and biodiversity in armored sediments do not appear to have been reported previously. Moreover, the importance of armoring to these

sedimentary and infaunal relationships has not been recognized. In this presentation, we will demonstrate the differences in the paradigms between these two sediment regimes and explain the process by which armoring develops.

176. DELAYED RECOVERY IN INTERTIDAL CLAM ASSEMBLAGES IN PRINCE WILLIAM SOUND FOLLOWING THE *EXXON VALDEZ* OIL SPILL CLEANUP

D.C. Lees[1] and W.B. Driskell[2]. [1]Littoral Ecological & Environmental Services, 1075 Urania Ave., Leucadia, CA 92024; [2]6536 20th Ave. NE, Seattle, WA 98115

Our studies of the effects of shoreline treatment on beaches oiled during the *Exxon Valdez* oil spill in Prince William Sound (PWS) from 1989 through 1996 suggested that bivalve assemblages on the beaches treated with high-pressure washing were severely injured in terms of abundance, species composition, and function. In 2002, we conducted a follow-up study to determine the generality and persistence of this injury in PWS. We found that the initial conclusions were accurate, i.e., a considerable proportion of mixed-soft beaches in treated areas of PWS remained extremely disturbed and were functionally impaired in terms of their ability to support foraging by humans and damaged nearshore vertebrate predators such as sea otters. Large, long-lived hard-shell clams, lprimarily littleneck and butter clams (*Protothaca staminea* and *Saxidomus gigantea*) remained 66% less abundant at Treated sites than at Reference sites. We also found that standard sediment properties did not appear implicated in lagging clam recovery. But, based on several lines of evidence, we deduced that a major cause for the delay was the disruption of surface armoring (a stratified organization of mixed-soft sediments common in southcentral Alaska) caused by beach washing. Based on the apparent recovery trajectory, we predict that recovery to pre-spill status will take several more decades

177. BALANCING RANIDS AND RECREATION: FOREST SERVICE EFFORTS TO PROTECT MOUNTAIN YELLOW-LEGGED FROGS AND QUALITY RECREATION OPPORTUNITIES

Gar Abbas, Anne Poopatanapong, and Marc Stamer. USDA Forest Service, San Bernardino National Forest, San Bernardino, CA 92408

The mountain yellow-legged frog (*Rana muscosa*, MYLF) was historically one of the most common frogs in Southern California being found in virtually every perennial stream in the San Jacinto, San Bernardino and San Gabriel Mountains. They have dramatically declined statewide and the Southern California population segment was listed as endangered in 2002. The National Forest system houses most of the last known MYLF populations in Southern California and the Forest Service is actively pursuing measures to protect remaining populations and promote recovery. The San Jacinto Mountains, on the San Bernardino National Forest, are home to one of the largest remaining populations of MYLF and some of the best available habitat for potential recovery. The San Jacinto Mountains are also located within a two hour drive of Los Angeles, and just outside Palm Springs, making these mountains a popular area for outdoor recreational activities. In 2001 the Forest Service started monitoring recreational use in the vicinity of MYLF habitats on the San Jacinto Ranger District to document any conflicts. This data and examples of adaptive management actions taken are presented along with descriptions of other efforts the Forest Service is locally involved in to protect and restore MYLF populations and habitats.

178. CHRONOTROPIC AND INOTROPIC EFFECTS OF HAWTHORN (*CRATAEGUS OXYCANTHA*) EXTRACTS IN CARDIOMYOCYTE-BASE ASSAY

Satin Salehi, Shannon R. Long, Kristi M. Crofoot, and Theresa M. Filtz. Oregon State University, College of Pharmacy, Corvallis, OR

Hawthorn is a fruit-bearing shrub with a long history as a medicinal substance. Hawthorn is used as an alternative therapy for a variety of cardiovascular conditions, including arrythmias and heart failure. Hawthorn extracts exhibit negative chronotropic and positive inotropic cardiac properties. The first aim of this study was to show the chronotropic property of hawthorn extracts on atrial and ventricular tissues in

a cultured neonatal murine cardiomyocyte assay. We tested several different preparations of hawthorn extract (commercial Heartcare® tablet extract, crude ethanolic extract of deried leaves and stems, or size exclusion column fractions of partially purified leaf and stem extract) and found that all decreased the rate of atrial cardiomyocyte contraction. However, differential effects were noted on atrial versus ventricular cardiomyocytes in culture. Ethanolic extract of dried leaves and stems had a multiple cardioactive components in the complex extract. We are attempting to isolate the negative chronotropic component of hawthorn extracts. The second aim was to discover a possible mechanism underlying the positive inotropic property of hawthorn extract in the cardiomyocytes. For this purpose, first we determined the effects of hawthorn on inositol phosphate (InsP)- formation in neonatal mice cardiomyocytes. In isolated ventricular cardiomyocytes, hawthorn tablet extract caused a concentration-dependent increase in InsP formation. Future investigations will focus on 1) hawthorn extract effects on inositol triphosphate (IP3) formation, and 2) muscarinic receptors involvement in hawthorn-induced InsP formation.

179. EFFECTS OF INCREASED CURRENT VELOCITY ON THE GROWTH OF JUVENILE CAPTIVE BROODSTOCK COHO SALMON (*ONCORHYNCHUS KISUTCH*)

John Silveus and Erick Sturm. Southwest Fisheries Science Center, National Marine Fisheries Service, 110 Shaffer Road, CA 95060

To help rehabilitate the endangered population of coho salmon, *Oncorhynchus kisutch*, in the waterways that flow into the Monterey Bay National Marine Sanctuary, the National Marine Fisheries Service is working with the Monterey Bay Salmon and Trout Project on a coho captive broodstock program. Data collected from spawning both captive broodstock and captured returning wild coho during the first two years of the program shows that on average, the captive broodstock fish are shorter and lighter than wild returning coho. It is important to rear larger captive broodstock females because larger females have higher fecundity rates, larger eggs, and a higher hatch out success than smaller females. One way to possibly rear larger females is with increased current velocity. Current velocities in the rearing tanks of the captive broodstock may not be representative of current velocities wild coho experience, and this could be a contributing factor in the observed difference in size between the wild fish and the captive broodstock. To test this hypothesis, two groups of young-of-year coho were reared for two months in identical tanks, one group had nominal current, and one group had increased current velocities of ½ to ¾ body-lengths per second. At the end of the trial period, no statistically significant ($P>0.05$) differences in weight or length were observed between the two treatments.

180. ADDITIONAL RECORDS FOR PACIFIC HADAL ZONE ECHINODERMS

K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037

The Scripps Institution of Oceanography Benthic Invertebrate Collection has three echinoderm lots from the hadal zone of the Pacific Ocean. A specimen of the holothurian species *Myriotrochus zenkevitchi* was collected at 7540 meters in the Peru Chile Trench. This is the second record for this species in the hadal zone of the Peru Chile Trench. *Myriotrochus zenkevitchi* is found in the hadal zone of the Pacific Ocean. Ten specimens of the holothurian species *Elpidia atacama* were collected at 6894 meters in the Peru Chile Trench. *Elpidia atacama* is restricted to the hadal zone of the Peru Chile Trench and this is only the second collecting record for this species. A specimen of the asteroid species *Eremicaster pacificus* was collected at 6650 meters in the Canton Trough. This is the first Central Pacific hadal zone record for this species. *Eremicaster pacificus* is a cosmopolitan species which has previously been reported from the hadal zone of the Eastern Indian Ocean, Western and Eastern Pacific Ocean and the Southern Ocean.

181. WHALE FALL DEPLETION AND ECOSYSTEM EFFECTS FOR ABYSSAL/HADAL MEGAFAUNA ECHINODERMS

K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037

The subject of whale hunting and the subsequent depletion of whale fall habitats has been discussed in light of the possible extinction of obligatory whale fall species. For abyssal zone megafauna echinoderms, the absence of whale fall habitats means the absence of a possible food source. Megafauna echinoderms in the abyssal zone are non-obligatory animals and are not dependent on whale fall habitats for survival. Echinoderms such as the holothuroid species *Scotoplanes globosa* and the echinoid species *Cystocrepis setigera* have used whale fall habitats as food sources. In the hadal zone, megafauna echinoderms may use whale falls as a more important food source because of the extreme hadal depths where other organic material sources are more limited. The holothuroid species *Elpidia glacialis* has diversified populations in different hadal trenches and in some instances have been trawled in very large numbers. The subspecies *Elpidia glacialis kermadecensis* has been collected in numbers up to 3000 individuals per trawl in the extreme depths of the Kermadec Trench. A significant food source in the hadal environment is required to sustain such large populations of holothurians. Whale falls are possible significant food sources for megafauna echinoderms in hadal environments.

182. DYNAMICS OF PLANETARY INTERIOR OCEANS AND SURFACE EXPANSION OF POTENTIAL ECOSYSTEMS

K.D. Trego. Nautilus Oceanic Institute, La Jolla, CA 92037

Internal oceans in solid planetary bodies in the solar system are potential ecosystems. The outer planet ice satellites with significant resurfacing (Europa, Enceladus, Dione) possibly have internal oceans with periodic surficial flow. Internal oceans of ice satellites have surficial flow due to tidal forces and volcanism. Possible organisms from these internal oceans might survive in the frozen surface of these ice satellites. On Mars, there may be a large aquifer system in the regolith that might be considered an internal ocean. Surficial oceans may have existed early in Mars' history. Resurfacing of an internal Martian ocean would result from volcanism and gravitational transport of unconsolidated material which would expose aquifer layers. Possible organisms of an internal Martian ocean may survive on the planet's frozen surface.

183. SEASONAL AGGREGATIONS OF FEMALE ROUND STINGRAYS (*UROBATIS HALLERI*) IN A COASTAL ESTUARY

C.G. Mull, K.A. Young, and C.G. Lowe. Department of Biological Sciences, California State University, Long Beach, CA 90840

Despite a large seasonal aggregation of round stingrays (*Urobatis halleri*) in Seal Beach, CA, no behavioral or physical evidence of mating has ever been observed. Mating in this population is thought to occur in nearby Anaheim Bay estuary, which is part of the Seal Beach National Wildlife Refuge (SBNWR). SBNWR is composed of 1.1 km^2 of estuary and four mitigation ponds. With muted tidal flushing, the mitigation ponds experience very seasonal temperature ranging from 10.9°C in winter to 29.3°C in summer. Round stingrays were sampled every other week from June 2005 to September 2006. All captured rays were weighed, sexed, and examined for mating scars as evidence of recent breeding behavior. From June 2006 to September 2006 blood was sampled via the caudal vein from a subset of rays and analyzed for progesterone and estradiol using radioimmunoassay. Rays exhibited strong sexual segregation with only one male being captured out of 428 rays sampled throughout the study period. There was little variance in size of adult females captured, with averages ranging from 188–203.5 mm disc width ($p>0.05$). Progesterone levels were elevated in females sampled through July and August (0.75 ng/ml) and levels decreased significantly to 0.16 ng/ml by September. The density of females appears to be regulated by temperature and correlated with reproductive state. Female round stingrays may be entering these warm shallow ponds to increase the gestation rate, purported to be three months, which is relatively short for a live bearing elasmobranch.

184. CIRCUIT DYNAMICS AND MODELING OF THE GAUSS ACCELERATOR

J. Luo and O.O. Bernal. California State University Los Angeles, Department of Physics and Astronomy, Los Angeles, CA 90032

The Gauss Accelerator, commonly known as the Gauss or Coil Gun, demonstrates potential for future use in military and space applications. However, efficiency is miniscule due to a lack of elucidation of factors that affect the performance of the Gauss Gun. But since the Gauss Gun functions as part of a time-dependent circuit, the circuit itself should play an immense role in the efficiency of the accelerator. Setting parameters for a theoretical, ideal circuitry and design of the Gauss Gun was attempted through the use of Fourier Transforms and Magnetic Field equations. The field model predicts that radial expansion of the Gauss Gun optimizes muzzle velocity and flux density, and energy calculations predict that on some level, higher circuit resistance is beneficial to the system. Experimental results show that between 0–10 amperes of current, 10 Amperes was least effective and 4 or 5 amperes were most effective for projectile distance. Fourier transformations also prove to be valuable tools for future optimization of time-dependent circuitry and dynamics of the Gauss Accelerator by frequency adjustments in AC.

185. A STUDY OF ENTEROBACTERIACEAE AT TWO ENCLOSED BEACHES IN LOS ANGELES, CALIFORNIA

S. Yanamadala and J.H. Dorsey. Chadwick School, 26800 S. Academy Drive, Palos Verdes, CA 90274

The purpose of this study is twofold. The first goal is to compare the densities of fecally derived bacteria found in two aquatic systems, to see if these differences could be attributed to bird populations, and to identify specific strains of these bacteria. The second goal is to compare relative fecal indicator bacterial densities in shore water and adjacent sand. This will help us better understand the microenvironment of our coastal estuaries and the influence of tidal variation on human illness. There were significantly higher bacterial levels in Del Rey Lagoon than in Mother's Beach, which may be attributed to the higher quantity and diversity in the Del Rey Lagoon. Although there was no significant difference between sand and water levels on all but one day, the standard deviations of the sand samples were often significantly higher, most likely due to the presence of bird feces in the sample collected. Based on the metabolic responses indicated by the VITEK system, the *E. coli* measurements obtained using the IDEXX system may represent a variety of Enterobacteriaceae species.The data produced will be valuable in developing a better understanding of the microenvironment of Southern California's water systems. Once the specific bacteria are identified, we can see whether these bacteria can be potential human pathogens. Source testing is the best way to assess the impacts of human usage and natural wildlife, which ultimately will impact water quality.

186. EXPLORATION OF PROTEIN LRP16'S FUNCTION AS A RESULT OF ITS CORRESPONDING DNA SEQUENCES THROUGHOUT THE EVOLUTIONARY TREE

Shahla Naimi. California Academy of Math and Science, Carson, CA 90747

Using computational methods and analysis, the protein structure of LRP16 was compared throughout six different species, allowing for variety of location on the evolutionary tree. The areas of conservation throughout evolution were located, analyzed, and determined to be primarily in the macro domain region. The predicted function of macro domain, an ADP-ribose bonding molecule, was determined and compared with the information from several recent studies suggesting the over-expression of LRP16 in breast cancer cells. The predicted function was concluded to suit the findings of another study, meaning it can potentially be a factor in the protein's over-expression. The results of this study suggest that the protein LRP16 is affiliated with breast cancer.

187. PERMANENT UPLIFT OF THE MENTAWAI ISLANDS AND THE MEGATHRUST EARTHQUAKE CYCLE

Hassan Ahmad. 501 N Chapel Ave. #1, Alhambra, CA 91801

The Sunda megathrust fault off the west coast of Sumatra, Indonesia has experienced big earthquakes in recent history. The section of the megathrust south of these ruptures, beneath the Mentawai Islands, could rupture in the coming decades. I mapped geomorphic features of the Mentawai Islands to observe evidence of any long term uplifting that might be tied to permanent uplift during great earthquakes. The features I focused on were flat terraces and uplifted sea cliffs. By mapping the distribution of terraces, I hope to identify uplift caused by previous earthquakes. I formulated the hypothesis that if the terraces on the islands are caused by permanent uplift due to earthquakes, then there should be apparent stair steps from the edges towards the center of the islands. I did not observe the stair steps of uplifted terraces, so there may be some other cause of the terraces I mapped. I conclude that there is not rapid uplift of the islands that is linked to each megathrust earthquake. Instead, each island could recover by sinking in between each earthquake. Field study in the islands would provide close observations of the terraces and help clarify why these islands don't simply rise with each earthquake.

188. PHYSICAL ASPECTS OF SOUTHERN CALIFORNIA BEACHES AND HOW PEOPLE PERCEIVE THEM: CONSIDERATIONS FOR BEACH NOURISHMENT PLANNING

Scott H. Grove. Sonora High School, La Habra, CA; California State University, Monterey Bay, CA

Southern California beaches are world famous and provide valuable economic, environmental, public safety, and shore protection benefits. Much attention is paid to beach width, erosion rates and shoreline change. And recently, economists have undertaken surveys and research to quantify the value of beaches to the local economy and the value of a day at the beach. To date, little attention has been paid to either the aesthetics of beaches or the public perception of beaches. This study attempts to characterize the physical aspects of beaches through a recent set of field surveys at 107 beach locations along 200 miles of the southern California coast. These findings are then compared to a "Beach Sand Survey" given to 225 people assessing how people perceive southern California beaches.

Results of the first part of this study show that beaches in southern California have a dramatic variety of widths as well as sand types, colors, and textures. Tan and light brown sands dominate the northern beaches and light gray to dark gray sands are common in San Diego. The "Beach Sand Survey" results reveal that people have a wide variety of reasons why they enjoy going to the beach – mainly involving exercise and relaxation. People also have wide ranging perceptions concerning our beaches. For example: While most prefer moderately wide beaches with fine texture sand, some favor very narrow and pebbly beaches, noting that these types of beaches may be adjacent to the best places for either surfing or tide pooling. The "Beach Sand Survey" also asks whether people are in favor of restoring Southern California beaches using beach nourishment if erosion has unfavorably narrowed them. People have mixed opinions regarding bringing new sand onto the beaches, yet the majority favor nourishment and are willing to pay an extra tax to have their beaches restored. The findings from this study may provide insight into future beach nourishment planning and may assist in understanding and/or establishing better beach management practices.

189. PRODUCTION AND CHARACTERIZATION OF EFFICIENT C60-TETHERED AU NANOPARTICLES FOR THE DELIVERY OF PHOTOSENSITIZERS

May Y. Chow[1] and Matthias Selke[2]. [1]Alhambra High School, Alhambra, CA 91801; [2]California State University, Los Angeles, CA

Singlet oxygen is the first excited state of oxygen that is a strong electrophile that can react with amino acids, peptides and other biologically relevant molecules. Here we study the oxidation of C-60 tethered Gold nanoparticles by singlet oxygen, $^1O_2$, for said nanoparticle's possible application as an efficient carrier of photosensitizers.

190. THE SIGNAL TRANSDUCTION PATHWAY FOR MUSCLE CELL APOPTOSIS IN AGING AND INJURY

Sanjit Datta and A.P. Sinha Hikim. Los Angeles Biomedical Research Institute at the Harbor-UCLA Medical Center, Harbor City, CA 90710

Muscle cell apoptosis has been implicated in the gradual loss of muscle mass in aging, also known as sarcopenia, as well as in cell death after muscle injury. It has been previously shown that an intrinsic (mitochondria-dependent) pathway causes this apoptosis. However, little is known about the key molecular components of the signal transduction pathway.

This study tested the two causes of apoptosis (aging and injury) with two separate arrangements of tissue samples from the mouse, Mus musculus. Tissues were taken from the gastrocnemius muscle after cardiotoxin injection (for the injury model) as well as from mice of different ages (for the senescence model). Changes in chemical concentrations such as G6PDH, 4-HNE, iNOS, BAX, and BCL-2 were examined with immunohistochemical analyses for the aging model; Western Blot techniques were used to analyze JNK and p38 MAPK induction. The results indicated that, in the aging model, oxidative stress slows the metabolism, causing JNK to phosphorylate BCL-2, perturbing the BAX/BCL-2 rheostat. This allows cytochrome c to escape from the mitochondria and activate caspase 9, which in turn activates the executioner caspases 3, 6, and 7. The same pathway seems to apply to muscle cell injury. The data showed that p38 MAPK and JNK are both activated after cardiotoxin injection; injury caused the same chemical changes as aging.

Overall, it has been shown the p38 MAPK and JNK are critical components of the apoptotic signaling pathway in injury and that oxidative stress and iNOS expression seem to be key elements of muscle cell loss in aging. This information will help to find a way to prevent sarcopenia and possibly remedy other muscular disorders.

191. A CASE-CONTROL STUDY OF COMMUNITY-ACQUIRED METHICILLIN RESISTANT *STAPHYLOCCUS AUREUS* SKINAND SOFT TISSUE INFECTIONS AMONG INMATES IN THE LOS ANGELES COUNTY JAIL

Ji-Mi (Jenny) Lee. California Academy of Mathematics and Science (CAMS), Carson, CA 90747; California State University, Dominguez Hills, 100 East Victoria Street, Carson, CA 90747

Staphylococcus aureus is among one of the most versatile of human pathogens. *S. aureus* causes illness through the production of cell surface and secreted virulence factors. The organism is highly adaptive and has proven ability to adapt to the selective pressures of antibiotics within a few years of their introduction. It can be a common cause of life-threatening infections causing end to many lives. The LA County Jail provides for an ideal opportunity to study this disease process in a near epidemic environment. Los Angeles County Jail and Los Angeles County Department of Health Services personnel have called for increased budgeting to deal directly with the continuing outbreak and are eager to have more answers as to the epidemiology of CA-MRSA. This gives a chance to further investigate on the growing problem of CA-MRSA. Nasal swabs and administering questionnaires were obtained during a two-week time of all inmates willing to participate being processed through the Inmate reception center (IRC). The second phase of the project will entail accessing inmates at the medical clinic in the jail. Preliminary results indicate inmates with prior history of being homeless are more likely to have CA-MRSA infections. There were some risk factors such as homelessness, carries MRSA/Staph infection, taken antibiotic pills or liquid by mouth, spent long time in jail, the use of needles for self-injecting medications or drugs, shared space with someone that has a skin infection, or shared personal items such as razors, soap, and sheets. The risk factors that were found to be significant were homelessness, consuming antibiotic pills or liquid by mouth or antibiotic injection within the past months. Shared personal items such as soap, sheets were also found to be significant.

192. THE ABILITY OF *BACCHARIS SALICIFOLIA* TO ABSORB CADMIUM AS AN EFFLUENT: IMPLICATIONS FOR PHYTOREMEDIATION: YEAR TWO

Nisha Wadhwa[1] and Katie Brandt[2]. [1]Palos Verdes Peninsula High School, Rolling Hills Estates, CA; [2]California State University, Dominguez Hills, CA

Cleanup of soil pollutants is often expensive and environmentally unsound. Phytoremediation is an area of frontier science that provides a safe and cost-effective alternative to the conventional cleanup methods. This study featured a native California plant, *Baccharis Salicifolia*, or mule fat, identified the maximum tolerable dose of cadmium that can be administered weekly as well as the implications for a large-scale phytoremediation project. The approximate maximum cadmium concentrations were determined by planting five groups of eight saplings. Cadmium was applied weekly via solutions of water and cadmium acetate in various doses. The saplings were observed during the eight-week growth period, and then harvested. Plant tissues were separated and analyzed via ICP-MS (Inductively Coupled Plasma Mass Spectroscopy), and cadmium content was determined in the leaves and shoots of various groups.

Average plant tissue dry masses in addition to leaf counts, shoot length measurements, and actual cadmium content in these tissues confirm that the maximum weekly dose tolerated by *Baccharis salicifolia* is somewhere between twenty-five and fifty parts per million. Beyond this level, the plant is no longer a practical phytoremediation candidate because the decline in overall health drastically decreases the mortality rate in the species.

As confirmed by the previous year's study, mule fat is a relatively plausible candidate for phytoremediation, though not necessarily better suited for cadmium as an effluent. Both a single large dose and multiple smaller doses demonstrate a similarly above-average tolerance for cadmium in Baccharis *salicifolia*.

193. PROTEASE INHIBITORS IN AUGMENT TEMOZOLOMIDE-BASED TREATMENT FOR MALIGANT GLIOMAS

J.J. Wang, W.J. Wang, and T.C. Chen. Department of Neurosurgery, University of Southern California, Los Angeles, CA 90033

The use of HIV protease inhibitors in conjunction with temozolomide (TMZ) based chemotherapy for patients with malignant gliomas has never been attempted before. Protease inhibitors, which were approved by FDA on May 1999, are orally administered, and are generally very safe and well tolerated by patients. Protease inhibitors have been previously demonstrated to have anti-tumor, anti-angiogenesis, and anti-invasive properties in Kaposi's sarcoma. In addition, recent data have indicated that the protease inhibitors have radio-sensitizing and chemo-sensitization properties as well. First of all, in this experiment, we propose to demonstrate via *in-vitro* models (glioma cell lines and cell cultures) that protease inhibitors may be additive or synergistic in inducing cytotoxicity during combination treatment with temozolomide based chemotherapy. The best type of protease inhibitor and the proper dosage will also be determined *in-vitro*. Second, we will apply the same conditions to an *in-vivo* nude mice subcutaneous and intracranial glioma model. If the hypothesis and specific aims of this researches are realized, adding a protease inhibitor to the temozolomide based chemotherapy regimen that is currently used for upfront management of malignant gliomas may be done more easily and safely, something that will hopefully reduce the malignant gliomas from a fatal disease to a less severe chronic illness.

194. OXIDATION OF L-DOPA IN MUSSEL BYSSUS DISC ADHESION

Renee Bogdanovic. Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274

This experiment's main goal was to further investigate the role of the amino acid L-Dopa in mussel (*Mytilus edulis*) byssal adhesion and understand its importance in attachment. L-Dopa, which requires oxygen to be activated, is a plentiful and persistent protein in the composition of these byssus threads, raising speculation as to its assistance in the process of adhesion.

This project was comprised of two sections of data collection. The first focused on creating an experimental environment which was deoxygenated to prevent L-Dopa from forming. Observations and comparisons were taken between a control tank and this lowered dissolved oxygen tank. Threads from each artificial habitat were sequestered and subjected to the Arnow Reaction which told of their L-Dopa content through coloration.

When the mussels were removed from their tanks, the differences in thread production between the two tanks was noted. The experimental tank, unlike the control tank, had zero attached threads although entire threads and byssal discs were fabricated. The Arnow Reaction also visually demonstrated through its coloring that the deoxygenated threads were clear. They contained less L-Dopa, thereby explaining their problems with functioning.

These results illustrate the true importance of L-Dopa in mussels byssal disc adhesion. This protein acts as the glue that ties many of the reactions together, making the attachment method effective. This valuable find does not only pertain to mussels but all of biochemistry for L-Dopa can be now studied in other applications, even applied to man-made adhesives.

195. STUDY ON THE TRUNCATION OF CONVEX SYMMETRICAL POLYHEDRA

Brian Li. Chadwick School, 26800 S. Academy Drive, Palos Verdes, CA

Truncations of convex symmetrical polyhedra were investigated. Truncation planes were created at each vertex such that the plane was perpendicular to the line from the center of the polyhedron to the vertex. These planes were pushed into the polyhedron with respect to a parameter and truncated the polyhedron. A computer algebra routine was created in order to automate this process and produce a new polyhedron with simply input of an original polyhedron and the parameter of truncation. Three types of truncation were encountered with respect to the depth of the cut. The first, a shallow truncation, was a truncation in which the truncations planes only interacted with the original polyhedron and not each other. This type of truncation related to a parameter value such that the cut was very shallow. A deep truncation occurred when the truncation planes began to interact with each other as well as with the old polyhedron. The final truncation, a dual truncation, occurred when only the truncation planes were interacting with each other to produce the new polyhedron. This point became a point of stability because any parameter value that cut further into the polyhedron would only scale the outcome of the dual truncation, which is the polyhedron's dual.

196. PREDICTING LUNG CANCER RELAPSE USING LEVELS OF 2881 PROTEINS

Timothy Wu[1] and Dennis Kibler[2]. [1]University High School, 4771 Campus Drive, Irvine, CA 92612; [2]University of California, Irvine, CA 92697

A major problem with cancer and other gene-related cases is that there is so much data to sift through. Even though scientists have been able to measure each of the approximately 25,000 genes in the human genome, they have no way of identifying patterns associated with gene-caused illnesses because the data range is so large. Even if the search were narrowed down to a relatively small number of genes, the potential for combinations between the genes would still generate a large search area. This study attempts to search through a bank of genes to find certain genes that are associated with lung cancer relapse. 2881 genes from 39 patients are analyzed by computer algorithms such as J48, IB1, and Naïve Bayes. Two genes were found to be significant. The importance of pattern finding and the significance of the two genes are talked about, as well as the importance of computers in aiding the search for causes of sicknesses related to genes.

197. PROTOCOLS FOR *HALIOTIS RUFESCENS* EGG CRYOPRESERVATION AND *IN VITRO* FERTILIZATION (YEAR 2)

Julie A. Guerin. Cabrillo Marine Aquarium, San Pedro, CA 90731; Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274

Gamete cryopreservation can play an important role in conservation strategies for at-risk abalone species. Objectives of this study were to continue investigating red abalone egg cryopreservation protocols by determining whether eggs which exhibit normal phenotypes after thawing could be successfully fertilized with live sperm, and by evaluating propylene glycol (PG) as an alternative cryoprotectant agent (CPA) to dimethyl sulfoxide (DMSO).

After induced spawning and egg collection, eggs were frozen using cooled or uncooled DMSO or PG at 8 and 16 mins stepwise cooling at 14, ≤4, −40 degrees C, before plunging into liquid nitrogen. 26 stepwise thawing protocols (5 mins at −40, ≤4, 14 degrees C with 1.25 g or 2.5 g non-permeating sucrose/80 ml water) and 20 *in vitro* fertilization tests were conducted.

Protocols using PG at 8 or 16 mins stepwise cooling and stepwise thawing at with 1.25 g sucrose, yielded 90% to100% (8 mins) and 75% to 80% (16 mins) intact round eggs with clear chorion. PG protocols using 2.5 g sucrose during thawing yielded less than 10% such eggs. DMSO stepwise cooling (8 and 16 mins) and stepwise thawing (1.25 g or 2.5 g sucrose) protocols yielded 10% to 25% intact round eggs displaying little or missing chorion. Sperm orientation towards eggs during *in vitro* fertilization attempts occurred only in PG trials. No cell division occurred.

PG appears to be the more effective CPA, as chemical signaling between sperm and eggs, with release of egg chemoattractant (L- tryptophan), remained bioactive after cryopreservation. CPA toxicity, ice

crystallization or other factors may have caused egg damage and prevented fertilization. Further research will involve refining protocols.

198. MAGNETORHEOLOGICAL FLUID SHEER STRESS AND THE MORPHING OF AIRPLANE WINGS

Anshu Vaish. Palos Verdes Peninsula High School, Rolling Hills Estates, CA 90274

Magnetorheological fluid is a prime example of today's smart fluids. The fluid is normally hydrocarbon based and contains suspended magnetic particles whose dipoles align with magnetic field exposure.

This project aims to study the shear stress of magnetorheological fluid. Shear stress is defined as stress which is directed parallel to the material's face, in this case the magnetorheological fluid. Furthermore, the project aims to provide a manner in which magnetorheological fluid can be applied to the morphing of airplane wings.

Shear stress measurements were taken as the magnetorheological fluid was exposed to varying magnetic fields generated by an electromagnet through which different voltages were run. The stress was measured using a simple pulley system and a glass plate which rested on a thin mm of the magnetorheological fluid. Upon activation of the magnetic field at varying voltages, weights were attached to the end of a string which ran over the pulley. The other end of this string was attached to the glass plate. Upon "shearing" one centimeter, the weight required was recorded and shear stress measurements were completed for the varying voltages. Measurements such as these were taken also at varying thicknesses of magnetorheological fluid.

As voltage of the electromagnet, and therefore magnetic field strength increased, the viscosity of the magnetorheological fluid also increased. This increase in viscosity correlated closely with an increase in shear stress; therefore, as voltage supplied increased shear stress increased.

Information gained from the sheer stress of magnetorheological fluid can be applied to the morphing of airplane wings. Airplane wings can be made to resemble a bird's wing with individual feathers. These individual "feathers" of a complete bird wing would be translated into several different pieces of a single airplane wing. Each "piece", through magnetorheological fluid shearing, can be shifted to varying positions to morph the wing as a whole.

INSTRUCTIONS FOR AUTHORS

The BULLETIN is published three times each year (April, August, and December) and includes articles in English in any field of science with **an emphasis on the southern California area**. Manuscripts submitted for publication should contain results of original research, embrace sound principles of scientific investigation, and present data in a clear and concise manner. The current AIBS *Style Manual for Biological Journals* is recommended as a guide for contributors. Consult also recent issues of the BULLETIN.

MANUSCRIPT PREPARATION

The author should submit at least two additional copies with the original, on 8½ × 11 opaque, nonerasable paper, double spacing the entire manuscript. Do not break words at right-hand margin anywhere in the manuscript. Footnotes should be avoided. **Manuscripts which do not conform to the style of the BULLETIN will be returned to the author.**

An abstract summarizing in concise terms the methods, findings, and implications discussed in the paper *must* accompany a *feature article. Abstract should not exceed 100 words.*

A feature article comprises approximately five to thirty typewritten pages. Papers should usually be divided into the following sections: abstract, introduction, methods, results, discussion and conclusions, acknowledgments, literature cited, tables, figure legend page, and figures. Avoid using more than two levels of subheadings.

A research note is usually one to six typewritten pages and rarely utilizes subheadings. Consult a recent issue of the BULLETIN for the format of *notes*. Abstracts are not used for notes.

Abbreviations: Use of abbreviations and symbols can be determined by inspection of a recent issue of the BULLETIN. **Omit periods after standard abbreviations:** 1.2 mm, 2 km, 30 cm, but Figs. 1–2. Use numerals *before* units of measurements: 5 ml, but nine spines (10 or numbers above, such as 13 spines). The metric system of weights and measurements should be used wherever possible.

Taxonomic procedures: Authors are advised to adhere to the taxonomic procedures as outlined in the International Code of Botanical Nomenclature (Lawjouw et al. 1956), the International Code of Nomenclature of Bacteria and Viruses (Buchanan et al. 1958), and the International Code of Zoological Nomenclature (Ride et al. 1985). Special attention should be given to the description of new taxa, designation of holotype, etc. Reference to new taxa in titles and abstracts should be avoided.

The literature cited: Entries for books and articles should take these forms.

McWilliams, K. L. 1970. Insect mimicry. Academic Press, vii+326 pp.

Holmes, T. Jr., and S. Speak.1971.Reproductive biology of Myotis lucifugus. J. Mamm., 54:452–458.

Brattstrom, B. H.1969.The Condor in California. Pp. 369–382 in Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii+635 pp.

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Annual Meeting of the Southern California Academy of Sciences

California State University, Dominguez Hills May 2–3, 2008

FIRST CALL FOR SYMPOSIA AND PAPERS

The Southern California Academy of Sciences will hold its annual Meeting for 2008 on the campus of California State University, Dominguez Hills Friday and Saturday May 2–3.

Presently the following symposia are in the planning stages. If you would like to organize a Symposia for this meeting, or have suggestions for a symposia topic, please contact John Roberts at jroberts@csudh.edu or Brad Blood at bblood@psomas.com. Organizers should have a list of participants and a plan for reaching the targeted audience.

Note: Abstracts will be due on March 24, 2008. Check our web page for further information (http://scas.jsd.claremont.edu/)

Proposed Symposia for 2008

Deep Sea Biology: Kent Trego (nautilusocianic@gmail.com)

Phylogeography of the American Southwest; Darren Sandquist (dsandquist@fullerton.edu)

Climate change: M. James Allen (Jima@sccwrp.org)

Restoration and Native Plants: Connie Vadheim (cvadheim@csudh.edu)

Reef Biology: Bob Grove (grovers@sce.com) and Dan Pondella (pondella@oxy.edu)

Coastal Sage Scrub Ecology: Darren Sandquist (dsandquist@fullerton.edu)

Threatened and Endangered Species of Southern California: Brad Blood (bblood@Psomas.com)

Runoff and Pollution Control: John Dorsey (jdorsey@lmu.edu)

Southern California Archaeology: Andrea Murray (apmurray@pasadena.edu)

Contributed papers: Sessions of Contributed Papers will occur both days.

Contributed Papers and Posters: Both professionals and students are welcome to submit abstracts for a paper or poster in any area of science. Abstracts are required for all papers, as well as posters, and must be submitted in the format listed on the society webpage. Maximum poster size is 32 × 40 inches.

In addition **Junior Academy members** will submit papers for Saturday sessions.

Abstracts of presented papers and posters will be published as a supplement to the August issue of the Bulletin.

Student Awards: Students who elect to participate are eligible for best paper or poster awards in the following categories: ecology and evolution, molecular biology,genetics and physiology, and physical sciences. In addition the American Institute of Fishery Research Biologists will award best paper and poster in fisheries biology. A paper by any combination of student and professional co-authors will be considered eligible provided that it represents work done principally by student(s). In the case of an award to a co-authored paper, the monetary award and a one year student membership to the Academy will be made to the first author only.

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106(3), 2007, pp. 163–178

Sediment Contaminant Patterns Within Coastal Areas of the Southern California Bight: Multivariate Analyses of Bight'98 Regional Monitoring Data

Charles R. Phillips

Science Applications International Corporation, 10260 Campus Point Drive, San Diego, CA 92121

Abstract.—Patterns in sediment metal, polycyclic aromatic hydrocarbon (PAH), chlorinated pesticide, and polychlorinated biphenyl (PCB) concentrations at 290 sites within coastal, port, harbor, and marina areas of the Southern California Bight (SCB) were evaluated using cluster analysis and principal components analysis (PCA). Cluster analysis identified five primary site groups, with two large groups representing 96% of the total area of the SCB. One of these two groups contained many of the open coastal sites, characterized by relatively coarse-grained sediments (~30% fines), low organic carbon, and low contaminant concentrations. The second large cluster group included a higher proportion of the embayment, marina, and harbor sites, with finer-grained sediments (~70% fines) and proportionately higher mean concentrations of most metals and trace organics. Both site groups were considered representative of SCB background conditions with minimal alterations from contaminant inputs. The other three site groups exhibited elevated concentrations of one or more contaminants, but accounted for only 4% of the total area of the SCB. In particular, two small cluster groups consisted mainly of port, harbor, and marina sites with elevated mean concentrations of certain metals (e.g., Cu, Pb, Sb, and Zn), as well as elevated chlordane, PAH, and PCB concentrations for one of the two site clusters. The fifth cluster group consisted of Palos Verdes Shelf sites that were characterized by high sediment DDT, PCB, Cd, and Ba concentrations, and clearly different from other open coastal sites in the SCB. PCA identified four principal components that explained 67% of the variance in the data set. The first two components (PC1 and PC2) accounted for 52% of the total variance. PC1 was highly loaded with a suite of metals (Cu, Pb, Hg, Zn, Al, and Fe), with high scores primarily for industrialized port and harbor sites. PC2 had high loadings for DDTs, PCBs, Cd, and Cr with highest scores for sites on the Palos Verdes Shelf. PC3 and PC4 each accounted for less than 10% of the total variance, with high loadings for low- and high-molecular weight PAHs and for a subset of metals (Ba, Ni, and Se) and fines, respectively. Although contaminant sources were not analyzed for this study, PC1 and, to a lesser extent, PC3 likely reflected recent industrial inputs to ports, commercial shipping and boatyard operations, and small marina activities. In contrast, PC2, reflected historical, wastewater-derived inputs to the Palos Verdes Shelf. Distinct sediment contaminant patterns were not evident for other large and small wastewater or riverine discharges.

Introduction

Nearshore portions of the Southern California Bight (SCB) are affected to varying degrees by chemical contaminants from multiple sources (Schiff et al., 2000; Eganhouse and Venkatesan, 1993). Contaminant sources include wastewater and industrial discharges, runoff from urbanized and agricultural areas, commercial and recreational vessel activities, oil and gas operations, and dredged material disposal, as well as atmospheric deposition and natural oil seeps (Anderson et al., 1993). Bottom sediments in coastal environments represent a potential sink for chemical contaminants, including many trace metals, organochlorines (e.g., DDTs and PCBs), and polycyclic aromatic hydrocarbons (PAHs) which typically have strong affinities for particles. Consequently, contaminant patterns in bottom sediments are expected to manifest the chemical characteristics as well as the magnitude and proximity to recent and historical inputs.

The Bight '98 Regional Monitoring Program collected sediment samples at 290 sites throughout coastal portions of the SCB including commercial ports, harbors, and marina areas (Bight '98 Steering Committee, 1998). Concentrations of suites of metals, organochlorines, and PAHs were analyzed using comparable, performance-based methods. Previous studies of sediment contaminants focused primarily on specific sites or portions of the SCB, such as Palos Verdes Shelf (Lee, 1994; Eganhouse et al., 2000), Port of Los Angeles (Malins et al., 1987), and San Diego Bay (McCain et al., 1992; Fairey et al., 1998), which represent only a small fraction of the total nearshore area of the SCB. The 1994 Southern California Bight Pilot Project (SCBPP; Schiff, 1999; Schiff and Gossett, 1998) provided synoptic sampling of coastal portions of the SCB, excluding ports and harbors, for a subset of possible contaminants. The state Bay Protection and Toxics Cleanup Program (BPTCP) evaluated sediment quality within several coastal harbors and embayments (e.g., Fairey et al., 1998; Phillips et al., 1998). State and national Mussel Watch programs evaluated water quality at fixed but widely-spaced, nearshore locations along the coastline and inside ports and harbors (O'Connor, 1996; Stephenson et al., 1995). Mearns et al. (1991) also characterized sediment quality within ports, harbors, and coastal portions of the SCB based on contaminant data from multiple studies conducted over a period of decades. Generally, however, these regional characterizations of sediment contaminant patterns have been limited by the lack of synopticity, methodological incompatibility, and spatially limited sampling. Therefore, the Bight '98 program provided a unique data set for evaluating input sources, pathways, and sinks of anthropogenic contaminants throughout the SCB.

This paper evaluates spatial and compositional patterns in the Bight'98 sediment contaminant data using the multivariate techniques cluster analysis and principal components analysis (PCA). Specifically, the objective was to identify sites with similar contaminant signatures and areal patterns that may infer sources and transport pathways. PCA and cluster analyses are particularly effective as exploratory tools for evaluating compositional patterns within large and complex data sets, and can reveal relationships among parameters and sampling locations that provide insight into contaminant sources and sinks. PCA was used previously by Phillips et al. (1997) to evaluate possible sources of sediment contaminants for the San Pedro Shelf area of the SCB, and cluster analysis was used by Anderson and Gossett (1987) to evaluate patterns in sediment PAH concentrations at 24 sites in the SCB. Although sediment contaminant patterns at selected sites within the SCB have been well-characterized by previous studies, multivariate analyses are considered useful for interpreting larger-scale spatial patterns which might be related to similar input sources or transport pathways. These results are also expected to provide a regional framework for interpreting sediment toxicity and biological community data.

Methods and Materials

Sediment samples were collected during July through September, 1998, at 290 sites throughout the SCB (Figure 1). The station array used for the Bight'98 Program was based on a variable-density, stratified random sampling design described by Stevens (1997). Sites were assigned *a priori* to one of nine strata – large publicly-owned treatment works (LPOTW), small POTW (SPOTW), mid-shelf POTW, river, shallow shelf, mid-shelf, marina, port, and bay/harbor. Samples were from the 0–2 cm surface layers of grabs (Van Veen grab) as representative of recently deposited sediments.

Analytical methods and data quality objectives for chemical analyses of sediment samples were described by the Bight '98 Steering Committee (1998). Target analytes and corresponding ranges in method detection limits (MDL) are listed in Table 1. Variations in MDLs for individual analytes reflected differences among participating laboratories in specific methods and capabilities. Although chemical analyses were performed by multiple laboratories, extensive intercalibrations were performed prior to and during the study to ensure data comparability (Gossett et al., 2003).

A complete data matrix was prepared for individual and summed variables listed in Table 2 and all 290 sites. Values corresponding to one-half the reporting limits were substituted for non-detectable results. Values for summed variables (e.g., total DDTs) represented the summed concentrations of all detected components, while concentrations of non-detected components were treated as zero. In cases where all components of summed variables were below detection limits, values corresponding to one-half the method detection limits for individual components were substituted, and surrogate values were summed. Prior to PCA, concentrations of individual variables were standardized by setting the mean to zero and variance to one. PCA then was performed on the correlation matrix, and factors were rotated using Varimax rotation to better align the directions of factors with the original variables, thereby making the factors more interpretable. Factor scores from the first four principal components were saved and analyzed by hierarchical cluster analysis

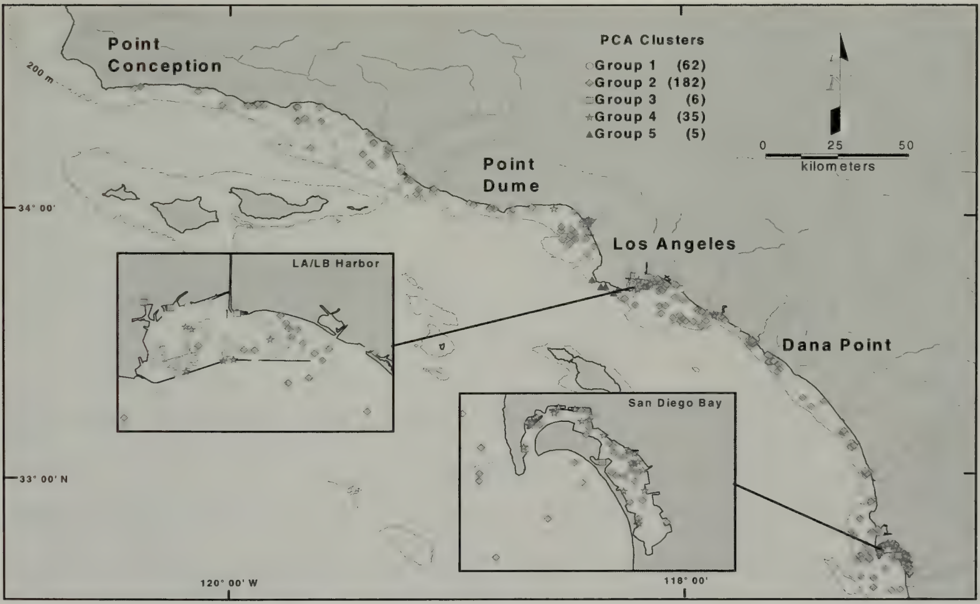

Fig. 1. Spatial Distributions of Site Clusters.

Table 1. Analytes and Method Detection Limit (MDL) Ranges for Bight '98 Sediment Samples.

Pest/PCBs	MDL (ng g^{-1})	PAHs	MDL (ng g^{-1})	Metals	MDL (µg g^{-1})
α -Chlordane	0.01–1	Naphthalene	5–36	Ag	0.06–0.2
γ -Chlordane	0.01–1	1-Methynaphthalene	5–39	Al	500
o,p'-DDD	0.02–1	2-Methylnaphthalene	5–39	As	0.08–0.62
o,p'-DDE	0.04–1	2,6-Dimethylnaphthalene	5–43	Ba	0.04–50
o,p'-DDT	0.02–1	1,6,7-Trimethylnaphthalene	5–39	Be	0.06–0.2
p,p'-DDD	0.03–1	Biphenyl	5–42	Cd	0.008–0.5
p,p'-DDE	0.02–1	Acenaphthene	5–42	Cr	1–16
p,p'-DDT	0.02–1	Acenaphthylene	5–25	Cu	1.9–7
PCB18	0.14–1	Fluorene	5–46	Fe	500
PCB28	0.24–1	Phenanthrene	5–37	Hg	0.005–0.2
PCB37	0.23–1.7	1-methylphenanthrene	5–29	Ni	1.2–4.2
PCB44	0.22–1	Anthracene	5–35	Pb	1–9.3
PCB49	0.17–1.3	Benzo(a)anthracene	5–26	Sb	0.05–10
PCB52	0.27–1.6	Benzo(a)pyrene	5–49	Se	0.11–1
PCB66	0.25–1	Benzo(e)pyrene	5–48	Zn	1.4–30
PCB70	0.22–1	Fluoranthene	5–39		
PCB74	0.23–7.9	Pyrene	5–27		
PCB77	0.13–3.7	Chrysene	5–36		
PCB81	0.19–4.7	Benzo(ghi)perylene	5–63		
PCB87	0.1–1.8	Benzo(b)fluoranthene	5–44		
PCB99	0.18–4.1	Benzo(k)fluoranthene	5–49		
PCB101	0.2–1.2	Indeno(cd)pyrene	5–33		
PCB105	0.18–1	Dibenzo(ah)anthracene	5–33		
PCB110	0.1–1	Perylene	5–34		
PCB114	0.1–1				
PCB118	0.21–1.1				
PCB119	0.17–1.2				
PCB123	0.13–9.6				
PCB126	0.11–1.1				
PCB128	0.06–8.9				
PCB138	0.13–1.9				
PCB149	0.17–1.7				
PCB151	0.14–1.1				
PCB153	0.44–1.2				
PCB156	0.1–1.8				
PCB157	0.15–5.6				
PCB158	0.09–1.1				
PCB167	0.12–5.0				
PCB168	0.44–1.4				
PCB169	0.19–1.7				
PCB170	0.17–1.6				
PCB177	0.22–2.3				
PCB180	0.19–2.7				
PCB183	0.15–1.4				
PCB187	0.2–1.3				
PCB189	0.18–1.6				
PCB194	0.15–1.8				
PCB201	0.2–2.3				
PCB206	0.29–5.8				

Table 2. Variables for PCA.

Metals	Ag, Al, As, Ba, Be, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Sb, Se, Se, Zn
Total DDT	Summed concentrations of detected o,p′- and p,p′- isomers of DDT, DDE, and DDD
Total PCB	Summed concentrations of detected congeners: 18, 28, 37, 44, 49, 52, 66, 70, 74, 77, 81, 87, 99, 101, 105, 110, 114, 118, 119, 123, 126, 128, 138, 149, 151, 153, 156, 157, 158, 167, 168, 169, 170, 177, 180, 183, 187, 189, 194, 201, 206
Total Chlord	Summed concentrations of detected α- and γ-chlordane
Low Molecular Weight PAH (LPAH)	Summed concentrations of detected two and three-ring PAHs: naphthalene, 1-methyl-, 2-methyl-, 2,6-dimethyl-, 1,6,7-trimethyl-naphthalenes, biphenyl, acenaphthene, acenaphthylene, fluorene, phenanthrene, 1-methylphenenathrene, anthracene
High Molecular Weight PAH (HPAH)	Summed concentrations of detected four and five-ring PAHs: fluoranthene, pyrene, chrysene, benzo(a)pyrene, benzo(e)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(cd)pyrene, dibenzo(ah)anthracene, perylene, benzo(ghi)-perylene
TOC	Total organic carbon
Fines	Silts + clays: particle diameter <63 microns

using the Ward clustering option. The number of primary cluster groups was selected by visually inspecting the plot of cluster distance between successive cluster joins in the dendrogram and distributions of data points for bivariate plots of principal component scores. PCA and cluster analyses were performed using JMP software (SAS Inst., 2001).

Area-weighted mean (AWM) concentrations for individual station clusters were calculated as follows:

$$m = \frac{\sum_{i=1}^{n} (p_i * w_i)}{\sum_{i=1}^{n} w_i}$$

where m = Area weighted mean concentration for population j, p_i = Parameter value (e.g., concentration) at station i, w_i = area weight for station i, equal to the inverse of the inclusion probability, n = Number of stations in population j. The standard error was calculated as follows:

$$\text{Standard Error} = \sqrt{\frac{\sum_{i=1}^{n} ((p_i - m) * w_i)^2}{\left(\sum_{i=1}^{n} w_i\right)^2}}$$

Confidence intervals were 1.96 times the standard error.

Results

Cluster Analysis

The dendrogram obtained from cluster analysis of PCA scores indicated five primary cluster groups (Figure 2) with varying numbers of sites per cluster (Table 3). Spatial distributions of the cluster groups are shown in Figure 1. The two largest cluster groups

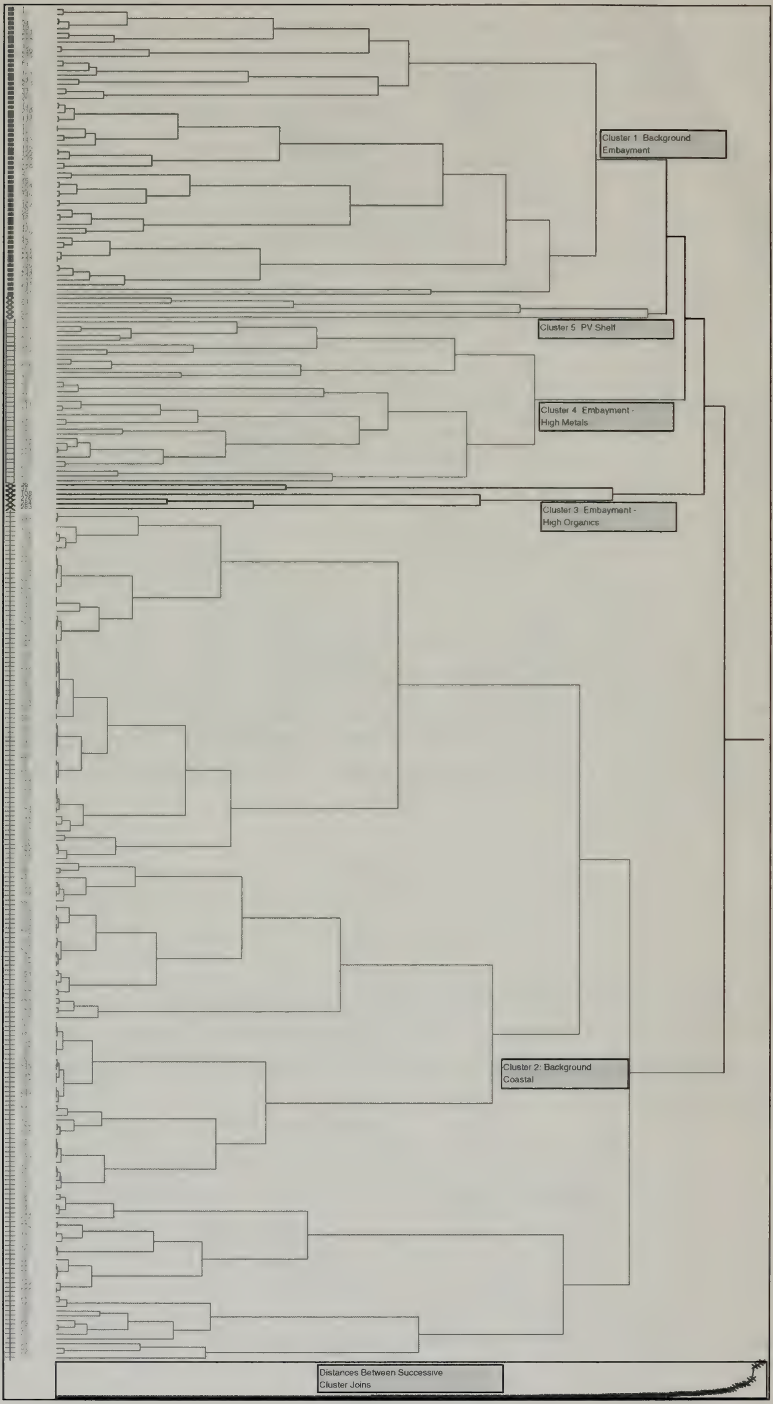
Cluster 1 Background Embayment
Cluster 5 PV Shelf
Cluster 4 Embayment - High Metals
Cluster 3 Embayment - High Organics
Cluster 2: Background Coastal
Distances Between Successive Cluster Joins

Fig. 2. Dendrogram from cluster analysis of PCA scores. Cluster distances between successive cluster joins are shown beneath the dendrogram.

Table 3. Summary of Cluster Analysis Results and Characterizations of Principal Site Cluster Groups.

		Area		Proportion of Sites by Strata[a]				
Cluster	No. Sites	km^2	%	POTW	River	Ports/ Harbor	Other Coastal	Description
1	62	704	22	14	8	58	19	Background Embayment
2	182	2,430	74	29	14	21	36	Background Coastal
3	6	8.7	0.3	0	17	84	0	Embayment – High Organics
4	35	89	3	0	0	97	3	Embayment – High Metals
5	5	47	1	80	0	0	20	Palos Verdes Shelf

[a] POTW = LPOTW, SPOTW, and mid-shelf POTW strata; River = river and river-gradient strata; Ports/Harbor = ports, harbors, marina, and other port strata; Other Coastal = shallow shelf, mid-shelf, and historical reference

(groups 1 and 2) accounted for 84% of the 290 sites and 96% of the corresponding study area, whereas the remaining three clusters combined accounted for only 46 of the sites and approximately 4% of the area.

Cluster group 2, which contained the largest number of sites and accounted for the greatest proportion of the study area, comprised 148 shelf and 38 embayment sites, consisting of shallow and mid-shelf (36%), LPOTW and SPOTW (13% and 16%, respectively), river (14%), and port/harbor/marina (21%) strata. All of the shallow- and mid-shelf sites on the 30-m and 60-m depth contours, coinciding with locations sampled historically for the SCCWRP Reference Site Surveys (SCCWRP, 1987, 1992), were part of this site cluster. Sediments were characterized by low proportions of fines, low TOC concentrations, and consistently lower contaminant concentrations than those of other cluster groups (Table 4).

Cluster group 1 comprised a relatively higher proportion of port, marina, and bay/harbor sites (21%, 24%, and 13%, respectively) and lower proportion of coastal (primarily mid-shelf, SPOTW, and river) sites, than group 2. Many of the coastal sites included in cluster group 1 were from a depositional region in the eastern Santa Barbara Channel characterized by relatively high proportions (46 to 99%) of fine-grained sediments, described previously by Kolpack (1986). Cluster group 1 sediments contained higher average TOC content, and, with the exceptions of Ag and Sb, higher contaminant concentrations than those in cluster group 2. These differences likely are due in large part to the relatively higher proportions of fines comprising cluster group 1 sediments and strong affinities of contaminants for fine-grained sediments.

With one exception (site 2382 in Santa Monica Bay), cluster groups 3 and 4 consisted exclusively of industrialized harbor and marina strata sites. Cluster group 3 contained three sites from Ports of Los Angeles/Long Beach, two sites from San Diego Bay, and one site in Marina del Rey. All of these sites were located in the inner portions of ports and harbors near industrial operations with limited circulation. Cluster group 4 comprised 21 port, harbor, and marina sites in San Diego Bay, seven marina sites in Newport and Marina del Rey harbors, six sites in Port of Los Angeles/Long Beach, and one shallow shelf site (2382) that, unlike the cluster group 3 sites, was not confined to the inner portion of industrialized harbor areas. Cluster groups 3 and 4 sediments typically contained elevated Cu, Hg, Pb, Zn, and Sb concentrations, whereas cluster group 3 sites also were distinguished by elevated LPAH, HPAH, PCB, and chlordane concentrations. Cluster group 5 comprised five sites on the Palos Verdes Shelf (four LPOTW and one shallow-shelf strata), generally northwest of the JWPCP outfalls, characterized by elevated DDT, PCB, Cd, and Ba concentrations.

Table 4. Area Weighted Mean Concentration by Cluster Group of Sediment Fines (%), TOC (%), Metals (μg g^{-1}), and Organics (ng g^{-1}). Numbers in parentheses are the lower and upper confidence limits.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
n	62	182	6	35	5
Fines	74 (65, 84)	30 (25, 35)	64 (48, 79)	62 (49, 75)	26 (0, 54)
TOC	1.5 (1.2, 1.7)	0.51 (0.43, 0.58)	2.2 (1.4, 2.9)	1.2 (0.87, 1.6)	2.2 (1.6, 2.8)
Ag	0.18 (0.13, 0.22)	0.38 (0.14, 0.61)	0.82 (0.01, 1.6)	1.6 (1.0, 2.1)	0.86 (0, 2.1)
Al	15,700 (13,600, 17,900)	9,000 (7,780, 10,200)	23,600 (14,300, 33,000)	26,100 (16,300, 36,000)	11,000 (5,420, 16,600)
As	8.7 (7.3, 10)	4.3 (3.8, 4.8)	11 (5.5, 17)	9.5 (8.2, 11)	8.9 (7.4, 10)
Ba	258 (170, 346)	82 (67, 96)	111 (48, 173)	111 (101, 122)	831 (527, 1,130)
Be	0.56 (0.48, 0.64)	0.43 (0.29, 0.57)	0.65 (0.22, 1.1)	0.74 (0.50, 0.98)	0.58 (0.47, 0.68)
Cd	0.57 (0.45, 0.69)	0.25 (0.18, 0.32)	0.66 (0.03, 1.3)	0.41 (0.27, 0.56)	2.9 (1.3, 4.4)
Cr	39 (36, 42)	22 (19, 26)	49 (23, 76)	51 (46, 55)	71 (17, 125)
Cu	24 (20, 29)	8.7 (7.4, 9.9)	85 (58, 112)	100 (43, 157)	33 (0, 71)
Fe	30,200 (25,100, 35,300)	14,800 (13,300, 16,400)	28,400 (16,6000, 40,200)	30,600 (24,800, 36,600)	21,000 (13,200, 28,700)
Pb	15 (12, 17)	11 (6.7, 14)	51 (26, 76)	60 (52, 68)	23 (5.7, 40)
Hg	0.10 (0.09, 0.12)	0.08 (0.06, 0.10)	0.24 (0.16, 0.32)	0.50 (0.26, 0.74)	0.20 (0, 0.40)
Ni	49 (31, 68)	12 (9.9, 13)	22 (9.2, 35)	22 (19, 25)	18 (11, 26)
Sb	0.42 (0.26, 0.58)	1.5 (1.0, 2.0)	4.4 (1.9, 7.0)	16 (2.3, 31)	0.83 (0.66, 1.0)
Se	1.5 (1.2, 1.8)	0.54 (0.40, 0.68)	0.46 (0.34, 0.58)	0.53 (0.40, 0.66)	0.60 (0.11, 1.1)
Zn	95 (82, 107)	40 (35, 45)	205 (114, 297)	161 (98, 224)	88 (31, 145)
Total Chlord	0.72 (0.45, 0.99)	0.42 (0.37, 0.47)	8.8 (0.71, 17)	1.3 (0.41, 2.2)	0.5 (0.5, 0.5)
Total DDT	42 (5.8, 79)	18 (7.0, 30)	91 (0, 187)	18 (11, 26)	1,600 (0, 3,290)
Total PCB	6.5 (2.5, 11)	4.6 (1.9, 7.3)	126 (3.2, 250)	21 (5.5, 37)	115 (3.2, 226)
LPAH	29 (7.7, 51)	15 (11, 18)	1,070 (596, 1,540)	55 (14, 96)	62 (0, 152)
HPAH	195 (111, 280)	27 (16, 38)	6,950 (4,070, 9,830)	569 (140, 997)	253 (0, 510)

PCA Results

The first four principal components of the PCA accounted for 67% of the total variance of the data set (Table 5). Principal components 1 and 2 (PC1 and PC2) explained 41% and 11%, respectively, of the variance, while PC3 and PC4 combined accounted for 16% of the variance. All other factors explained less than 5% of the variance and were not retained for further evaluation.

The highest PC1 loadings were for Cu, Hg, Zn, Pb, Al, and Fe. High factor loadings imply that these metals contributed to and strongly influenced the principal component (Zitko, 1994). The highest scores for PC1 corresponded primarily to harbor and port strata sites, especially in San Diego Bay and Ports of Los Angeles/Long Beach, as well as marina strata sites within Newport and Marina del Rey harbors and LPOTW strata sites near wastewater outfalls on the Palos Verdes Shelf. Factor scores give the positions of the samples in coordinates of the principal components, and the magnitude of scores corresponds to the extent to which individual sites reflect these attributes (i.e., elevated concentrations of metals with high loadings) and the amount of information for that site explained by the factor. High loadings for Fe and Al suggest that PC1 also included portions of the variance associated with natural patterns in sediment geochemistry (Schiff and Weisberg, 1999).

The highest loadings on PC2 were for DDT, PCB, Cd, and Cr. High PC2 scores were, with minor exceptions, associated exclusively with LPOTW strata sites near the JWPCP and Hyperion outfalls on the Palos Verdes Shelf and Santa Monica Bay, respectively. Low and high molecular weight PAHs and, to a lesser extent, chlordane had the highest loadings on PC3. The highest PC3 scores were associated with port strata sites in San Diego Bay and Ports of Los Angeles/Long Beach and LPOTW strata sites associated with JWPCP and Hyperion outfalls. PC4 appeared to be associated mainly with Se, Ni, Ba, and fines, although the magnitude of the highest loading values were all less than 0.8. Sites with the highest PC4 scores corresponded to LPOTW, port, and marina strata, especially within San Diego Bay.

Bivariate plots of PCA scores shown in Figure 3 illustrate differences in sediment contaminant patterns for individual cluster groups. Density ellipses were computed from the bivariate normal distribution fits to the X and Y variables, and the ellipses delineate expected distributions of 95% of the data (PCA scores) for individual cluster groups. Relatively large ellipses associated with cluster groups 3 and 5 reflect the correspondingly large variances in contaminant concentrations. The plot of PC1 versus PC2 shows separation along PC1 for cluster groups 3 and 4, reflecting the elevated concentrations of highly loaded metals (e.g., Cu, Zn, and Pb) within these port and harbor sites, and separation of cluster group 5 along PC2 associated with elevated concentrations of DDT, PCB, and Cd on the Palos Verdes Shelf. Although cluster group 2 overlapped with that of cluster group 1, the positive offset along PC1 reflected the consistently higher mean sediment metal concentrations associated with the cluster group 1 sites. Biplots of PC2 versus PC3 show considerable overlap along PC3 for all but cluster group 3, reflecting the presence of elevated PAH concentrations at these inner harbor sites.

Discussion

Spatial patterns for sediment contaminants described by PCA and cluster analyses were internally consistent and, with some exceptions, in general agreement with results from previous site-specific and regional SCB studies (e.g., Mearns et al., 1991). PCA and cluster analyses indicated that the major portion (74%) of the SCB, primarily comprising

Table 5. Rotated Factor Pattern for PCA Factors (PC 1–4). Italicized numbers are factor loadings >0.6 or <−0.6.

	PC1	PC2	PC3	PC4
Ag	0.321	0.585	−0.032	0.053
Al	*0.793*	−0.057	0.159	−0.368
As	0.496	0.147	0.201	−0.063
Ba	−0.003	0.276	−0.032	*−0.602*
Be	0.464	0.081	0.058	−0.282
Cd	0.069	*0.823*	0.126	−0.355
Cr	0.551	*0.639*	0.165	−0.414
Cu	*0.838*	0.095	0.227	−0.078
Fe	*0.706*	0.075	0.177	−0.588
Hg	*0.750*	0.208	0.096	0.045
Ni	0.206	0.075	0.125	*−0.643*
Pb	*0.734*	0.244	0.299	−0.176
Sb	0.487	0.062	−0.118	0.301
Se	−0.012	0.086	0.096	*−0.722*
Zn	*0.799*	0.136	0.405	−0.285
Total Chlord.	0.093	0.016	0.594	−0.187
Total DDT	−0.034	*0.874*	0.035	−0.111
Total PCB	0.197	*0.708*	0.558	−0.123
LPAH	0.146	0.163	*0.896*	−0.046
HPAH	0.239	0.035	*0.861*	0.015
TOC	0.451	0.281	0.382	−0.534
Fines	0.577	−0.054	0.187	*−0.607*
% Total Variance	40.7	10.6	8.7	7.3

areas of the open coast and shelf represented by cluster group 2, was characterized by sediments with generally low contaminant concentrations. The exception, represented by cluster group 5, reflected the uniqueness of the Palos Verdes Shelf compared to other shelf sites. A second group of sites represented by cluster group 1, comprising 22% of the SCB area, included harbor sites characterized by finer grained sediments with a higher organic content than those for cluster group 2. Although the average contaminant concentrations were higher than those of cluster group 2 sites, the differences were consistent with the higher proportions of fine grained sediments and not necessarily due to greater contaminant inputs. Cluster groups 3 and 4 represented subsets of port, harbor, and marina sites containing elevated sediment contaminant concentrations but, together with cluster group 5, represented less than 5% of the SCB area.

Although results from the multivariate analyses were consistent with previous studies, they did not indicate a close correspondence between cluster groups and the original site strata. Instead, primary distinctions appeared to be between relatively uncontaminated (cluster groups 1 and 2) and contaminated (cluster groups 3, 4, and 5) sites, while distinctions between cluster groups 1 and 2 appeared to be driven by differences in grain size and proportional differences in bulk contaminant concentrations. The background clusters included sites from all strata. Other than the JWPCP outfalls on the Palos Verdes Shelf, LPOTW strata sites near the Hyperion, OCSD, and Point Loma outfalls, and most SPOTW sites, were associated with cluster group 2 and, to a lesser extent, with cluster group 1. Associations of LPOTW sites near the OCSD and Point Loma outfalls with the background coastal site cluster are reasonable based on the general absence of significant sediment contamination in the vicinity of these outfalls (Phillips et al., 1997; Zeng and

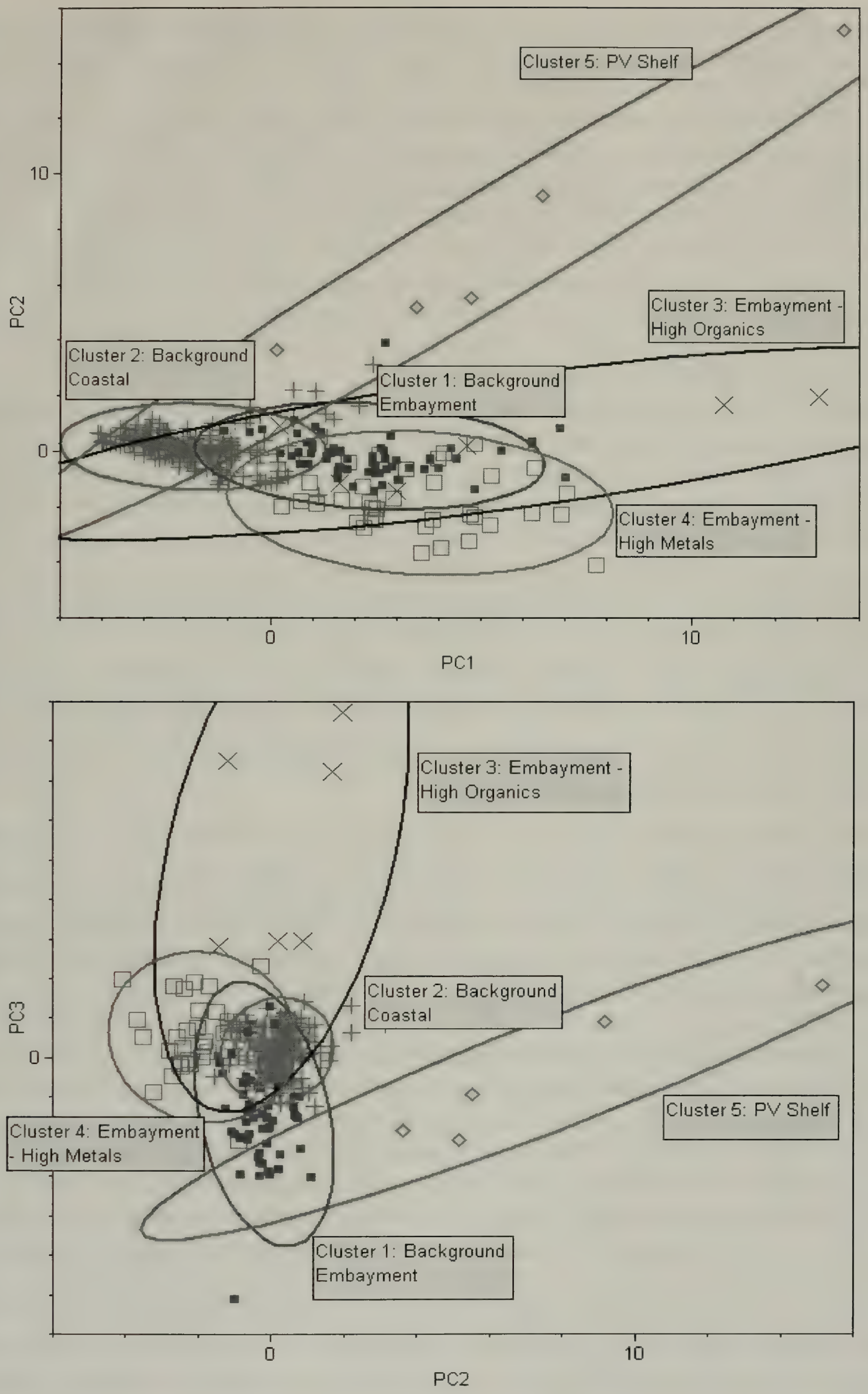

Fig. 3. Bivariate plots of principal component scores: (A) PC1 vs PC2 and (B) PC2 vs PC3. 95% Density ellipses are shown for individual site clusters.

Vista, 1997). In contrast, sediments in the vicinity of the Hyperion outfall in Santa Monica Bay contained elevated Ag (1.4–7.5 μg g^{-1}), Hg (0.13–0.7 μg g^{-1}), and DDT (up to 100 ng g^{-1}) concentrations, and sites near the outfall terminus had high scores for PC2 and PC3. During the 1994 SCBPP, approximately 80% of the sites in Santa Monica Bay were enriched in three or more metals, especially Ag, Cd, and Cr (Schiff and Weisberg, 1999) that likely represented residual contamination from discontinued sludge discharges (Zeng and Venkatesan, 1999). Regardless, sediment contaminant patterns near the Hyperion outfall appear to be more similar to those of other shelf areas described by cluster group 2 than to contaminant patterns associated with the Palos Verdes Shelf and cluster group 5. However, removal of outlier data associated with the Palos Verdes Shelf sites likely would have resulted in greater distinctions for cluster analysis between Hyperion and other LPOTW sites.

It is also noteworthy that other than a single site near the mouth of the Los Angeles River, in the Port of Long Beach, river strata sites occurred only in the background cluster groups 1 and 2. Sediments from river mouth locations did not exhibit any discernable chemical signatures (i.e., for the suite of measured contaminants) other than slightly elevated chlordane concentrations, that might be associated with runoff. Chlordanes were moderately loaded on PC3, but this factor explained less than 10% of the total variance of the data set, and none of the river strata sites had particularly high scores for PC3. The absence of a strong runoff signal may be due in part to physical mixing processes which typically minimize deposition and accumulation of particle-associated contaminants at the mouths of coastal rivers. Regardless, this is contrary to expectations because previous studies have indicated that river discharges can be significant sources of runoff-derived pollutants as well as fine-grained sediments to coastal areas of the SCB (Schiff et al., 2000).

While cluster groups 1 and 2 were characterized as background sites for embayment and open coastal areas, respectively, it is useful to compare the area-weighted mean (AWM) concentrations calculated for these cluster groups to corresponding reference values reported previously for the SCB (Table 6). Cluster group 2 AWM values for metals and several organic contaminants were generally comparable to average concentrations reported for the 1985 and 1990 Reference Site Surveys (SCCWRP, 1987, 1992), as well as AWM concentrations for reference site locations sampled as part of the Bight'98 program. The AWM metal concentrations for cluster groups 1 and 2 also show reasonably good agreement with values predicted using regression coefficients for baseline metal:iron relationships developed by Schiff and Weisberg (1999) for non-enriched sediments within the SCB. This further supports the characterization of cluster group 2 sediments as representative of "background coastal" conditions. However, the AWM concentrations for Ag, Cd, and Pb in cluster group 2 sediments were up to severalfold higher than predicted baseline levels, indicating some degree of sewage- and/or runoff-derived contamination. Furthermore, sediments from cluster groups 1 and 2 typically contained measurable amounts of synthetic organic compounds (DDT, PCB, and chlordanes) which are not consistent with pollution-free conditions. This is not surprising given that the SCBPP detected DDT in 89% of the SCB sediments during 1994 (Schiff et al., 2000), and Schiff and Weisberg (1999) concluded that 61% of SCB sediments contained elevated concentrations of one or more metals. Therefore, while the AWM concentrations reflect minimal apparent alterations and represent background conditions throughout a large portion of the SCB, cluster groups 1 and 2 sediments were not "pollution-free". In many cases, the distributions of concentration values for

Table 6. Comparisons of Bight '98 Cluster Area Weighted Mean (AWM) and Baseline Concentrations.

	Measured AWM		Predicted[a]		1985 and 1990 Reference Site Surveys[b]				Bight '98 Historical Sites[c]		Pollu-tion-Free Baseline[d]
	Cluster 1	Cluster 2	Cluster 1	Cluster 2	30 m	60 m	30 m	60 m	30 m	60 m	
Ag	0.18	0.38	0.22	0.10	0.01	0.03	0.1	0.25	0.30	0.30	0.4
As	8.7	4.3	7.2	4.3					3.2	4.3	
Cd	0.57	0.25	0.30	0.15	0.13	0.14	0.26	0.24	0.21	0.18	0.4
Cr	39	22	50	24	18	25	17	26	14	20	25
Cu	24	8.7	20	9.0	5.7	10	5.3	9.2	5.6	9.1	9
Fe	30,200	14,800					11,000	18,000	10,600	15,400	
Pb	15	10	14	7.3	2.9	4.8	4.4	6.9	7.0	5.2	10
Ni	49	12	29	14	9.0	13	8.0	11	7.3	11	15
Zn	95	40	93	45	31	48	29	45	29	39	44
Total DDT	42	18			9.1	19	5.4	13	3.9	6.9	
Total PCB	6.5	4.6			11	19	7.1	12	0.5	1.2	
LPAH	29	15							20	20	
HPAH	195	27			39	20	24	26	32	29	

[a] Predicted values based on baseline regression coefficients (slope and intercept) for metal:iron relationships in SCB sediments from sites distant from known point and non-point sources of pollution developed by Schiff and Weisberg (1999).

[b] Average values for 30-m and 60-m sites sampled in 1985 and 1990 for the SCCWRP Reference Site Surveys (SCCWRP, 1987, 1992); total DDT is the sum of five isomers, total PCB is sum of two Aroclors, and HPAH represents sum of 30 LPAH and HPAH.

[c] Averages for historical 30-m and 60-m sites corresponding to SCCWRP Reference Site Survey locations.

[d] from Katz and Kaplan (1981).

individual parameters, as represented by the 95% confidence intervals, for cluster groups 1 and 2 overlapped with those of the other site clusters (Table 4). This illustrates the difficulty distinguishing contaminated sediments based on bulk contaminant concentrations, which has important implications for regulatory-based programs such as waste discharge monitoring and dredged material testing.

In contrast with cluster groups 1 and 2, sites comprising cluster groups 3, 4, and 5 were characterized by elevated concentrations of various metals, PAHs, and organochlorines. Several of these sites, particularly in cluster groups 3 and 5, exhibited consistently high scores on one or more of the PCA factors. Regardless, the magnitude of measured contaminant concentrations was consistent with those reported by previous studies and therefore considered reasonable descriptions of SCB sediment contaminant patterns. In particular, the magnitude and distributions of contaminants such as DDT and PCB in Palos Verdes Shelf sediments have been well-documented. Previous studies (Lee, 1994; Eganhouse and Pontolillo, 2000) concluded that histories of waste emissions to the Palos Verdes Shelf were recorded in the depositional chronologies of sediment cores. Further, surface contaminant concentrations on the Palos Verdes Shelf remain elevated despite large reductions in mass emissions. The presence of contaminants in surface sediments may be due to bioturbation and remobilization of historically buried sediments with elevated contaminant concentrations. Other studies have also indicated that remobilized contaminants are subject to dispersion to other areas of the SCB (Zeng and Venkatesan, 1999). As a result, the Palos Verdes Shelf represents a secondary source for DDT to other parts of the SCB, and may contribute to the presence of measurable organochlorines in cluster group 2 sediments. Because the Palos Verdes Shelf is a reservoir for large quantities of DDT and PCB, and remobilization of contaminants represents an ongoing threat to biological resources and human health, sediment remediation and contaminant management projects are being evaluated to address these issues (Palermo et al., 1999).

Embayment sites contributing to cluster groups 3 and 4 were characterized by elevated concentrations of selected metals and PAHs that may be from industrial input sources. Elevated metal (Cu, Hg, and Zn) concentrations can be associated with multiple source types that include industrial activities, hull cleaning and dissolution of anti-fouling hull paints in ports, harbors, and marinas, and urban runoff. Elevated PAH concentrations in sediments at cluster 3 sites included both high and low molecular weight compounds associated with both petroleum and combustion sources potentially derived from fuel spills and urban runoff. Sediment contaminants at the cluster group 3 sites likely reflect proximity to input sources as well as hydrological properties that promote deposition and accumulation of particulate-bound contaminants within the inner portions of industrialized harbors, such as commercial slips and dredged channels with limited circulation.

Compositional data for contaminant input sources to the Bight (e.g., POTW discharges, river and urban runoff, atmospheric deposition) are not presently available to support source apportionment estimates. Additionally, it should be noted that while sediments collected for this program were from the surface 2-cm layer of grab samples, deposition rates are expected to vary considerably throughout the Bight. Also, some areas within harbors and marinas may have been dredged prior to sampling. Thus, contaminant levels in sediments measured at individual sites were not necessarily representative of inputs over the same, fixed time period. Regardless, the overall patterns indicated by these results should be useful for interpreting patterns in biological communities, comparisons between bulk contaminant concentrations and effects thresholds, and sediment bioassay results from the Bight '98 and subsequent regional monitoring programs.

Conclusions

Of the five station groups delineated by cluster analysis, two groups comprising the majority of coastal and embayment sites and representing 94% of the study area, were characterized by relatively low contaminant concentrations. The primary distinction between the two station groups appears to be related to relatively finer sediment texture, and correspondingly higher contaminant concentrations, at embayment sites. The other three station groups were characterized by elevated concentrations of one or more contaminant classes but represented a relatively small portion of the total area of the SCB. Two of the cluster groups consisted almost exclusively of sites from enclosed portions of industrialized ports and marinas with high sediment trace metal and organic concentrations. The final site cluster comprised Palos Verdes Shelf sites, which reflected residual contamination from historical waste discharges. By contrast, other POTW and river sites lacked distinctive chemical signatures and were largely indistinguishable from other open-coastal background sites.

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References

Anderson, J.W. and R.W. Gossett. 1987. Polynuclear Aromatic Hydrocarbon Contamination in Sediments from Coastal Waters of Southern California. Final Report to California State Water Resources Control Board, Sacramento, CA.

———, D.J. Reish, R.B. Spies, M.E. Brady, and E.W. Segelhorst. 1993. Human impacts. Chapter 12 In M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA.

Bight '98 Steering Committee. 1998. Southern California Bight 1998 Regional Marine Monitoring Survey: Coastal Ecology Workplan, Pp. 9,58–59 (Appendix B).

Eganhouse, R.P. and J. Pontolillo. 2000. Depositional history of organic contaminants on the Palos Verdes Shelf, California. Mar. Chem., 70:317–338.

———, ———, and T.J. Leiker. 2000. Diagenetic fate of organic contaminants on the Palos Verdes Shelf, California. Mar. Chem., 70:289–315.

——— and M.I. Venkatesan. 1993. Chemical oceanography. Chapt. 3 In M.D. Dailey, D.J. Reish, and J.W. Anderson (eds.). Ecology of the Southern California Bight: A Synthesis and Interpretation. University of California Press, Berkeley, CA.

Fairey, R., C. Roberts, M. Jacobi, S. Lamerdin, R. Clark, J. Downing, E. Long, J. Hunt, B. Anderson, J. Newman, R. Tjeerdema, M. Stephenson, and C. Wilson. 1998. Assessment of sediment toxicity and chemical concentrations in the San Diego Bay region, California USA. Environ. Toxicol. Chem., 17:1570–1581.

Gossett, R.W., R. Baird, K. Christensen, and S.B. Weisberg. 2003. Making performance-based chemistry work: How we created comparable data among laboratories as part of a Southern California marine regional assessment. Environ. Monitor. and Assess., 81:269–287.

Katz, A. and I.R. Kaplan. 1981. Heavy metals in coastal sediments of Southern California: A critical review and synthesis. Mar. Chem., 10:261–299.

Kolpack, R. 1986. Sedimentology of the mainland nearshore region of Santa Barbara Channel, California. Pp. 57–72 In R.J. Knight and J.R. McLean (eds.). Shelf Sands and Sandstones. Canadian Society of Petroleum Geologists, Memoir II.

Lee, H.J. 1994. The Distribution and Character of Contaminated Effluent Affected Sediment, Palos Verdes Margin, Southern California. Expert Report 2, Southern California Damage Assessment Witness Report, October 4, 1994. 261 pp.

Malins, D.C., B.B. McCain, D.W. Brown, M.S. Myers, M.M. Krahn, and S. Chan. 1987. Toxic chemicals, including aromatic and chlorinated hydrocarbons and their derivatives, and liver lesions in white croaker (*Genyonemus lineatus*) from the vicinity of Los Angeles. Environ. Sci. Technol., 21: 765–770.

McCain, B.B., S.-L. Chan, M.M. Krahn, D.W. Brown, M.S. Myers, J.T. Landahl, S. Pierce, R.C. Clark, Jr., and U. Varanasi. 1992. Chemical contamination and associated fish diseases in San Diego Bay. Environ. Sci. Technol., 26:725–733.

Mearns, A.J., M. Matta, G. Shigenaka, D. MacDonald, M. Buchman, H. Harris, J. Golas, and G. Lauenstein. 1991. Contaminant Trends in the Southern California Bight: Inventory and Assessment. NOAA Tech. Memo. NOS ORCA 62. NOAA, Seattle, WA.

O'Connor, T.P. 1996. Trends in chemical concentrations in mussels and oysters collected along the US coast from 1986 to 1993. Mar. Environ. Res., 41:183–200.

Palermo, M., P.R. Schroeder, Y. Rivera, C. Ruiz, D. Clarke, J. Gailani, J. Clausner, M. Hynes, T. Fredette, B. Tardy, L. Peyman-Dove, and A. Risko. 1999. Options for *In Situ* Capping of Palos Verdes Shelf Contaminated Sediments. Technical Report EL-99-2, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. (available at http://www.wes.army.mil/el/elpubs/pdf/trel99-2.pdf).

Phillips, C.R., M.I. Venkatesan, and R. Bowen. 1997. Interpretations of contaminant sources to San Pedro Shelf sediments using molecular markers and principal components analysis. Chapter 16 In R.P. Eganhouse (ed.). Molecular Markers in Environmental Geochemistry. American Chemical Society, Washington, D.C., USA.

Phillips, B., B. Anderson, J. Hunt, J. Newman, R. Tjeerdema, C.J. Wilson, E.R. Long, M. Stephenson, M. Puckett, R. Fairey, J. Oakden, S. Dawson, and H. Smythe. 1998. Sediment Chemistry, Toxicity and Benthic Community Conditions in Selected Water Bodies of the Santa Ana Region. Report to the State Water Resources Control Board, Sacramento, CA.

SAS Inst. 2001. JMP Statistics and Graphics Guide, Version 4. SAS Institute, Cary, NC.

SCCWRP. 1987. Reference Site Survey, 1985. SCCWRP Technical Report 221. Southern California Coastal Water Research Project, Long Beach, CA.

SCCWRP. 1992. 1990 Reference Site Survey. SCCWRP Technical Report 355. Southern California Coastal Water Research Project, Long Beach, CA.

Schiff, K.C. 1999. Sediment chemistry on the mainland shelf of the Southern California Bight. Pp. 76–88 In S.B. Weisberg and D. Hallock (eds.), SCCWRP Annual Report, 1997–1998. Southern California Coastal Water Research Project, Westminster, CA.

——— and R.W. Gossett. 1998. Southern California Bight 1994 Pilot Project. III. Sediment Chemistry. Southern California Coastal Water Research Project, Westminster, CA.

——— and S.B. Weisberg. 1999. Iron as a reference element for determining trace metal enrichment in Southern California coastal shelf sediments. Mar. Environ. Res., 48:161–176.

———, M.J. Allen, E.Y. Zeng, and S.M. Bay. 2000. Southern California. Mar. Poll. Bull., 41:76–93.

Stephenson, M.D., M. Martin, and R.S. Tjeerdema. 1995. Long-term trends in DDT, polychlorinated biphenyls, and chlordanes in California mussels. Arch. Environ. Contam. Toxicol., 28:443–450.

Stevens. 1997. Variable density grid-based sampling designs for continuous spatial populations. Envirometrics, 8:167–195.

Zeng, E.Y. and M.I. Venkatesan. 1999. Dispersion of sediment DDTs in the coastal ocean off southern California. Sci. Total Environ., 229:195–176.

——— and C.L. Vista. 1997. Organic pollutants in the coastal marine environment off San Diego, California. I. Source identification and assessment by compositional indices of polycyclic aromatic hydrocarbons. Environ. Toxicol. Chem., 16:179–188.

Zitko, V. 1994. Principal component analyses in the evaluation of environmental data. Mar. Poll. Bull., 28: 718–722.

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Wet and Dry Weather Toxicity in the San Gabriel River

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Abstract.—The lower San Gabriel River is an urban watershed located on the border of Los Angeles and Orange Counties. It has a diversity of potential pollutant sources including five water reclamation plants (WRPs) that discharge treated wastewaters and more than 100 storm drains that discharge largely untreated urban runoff to the river. The goal of this study was to assess the magnitude of toxicity to *Ceriodaphnia dubia* throughout the lower San Gabriel River watershed during wet and dry weather, identify the responsible toxicants, and compare the magnitude of toxicity over time to evaluate the effectiveness of previous watershed management actions. Wet weather runoff was sampled from sites located at the end of the four main reaches of the lower San Gabriel River; Walnut Creek, San Jose Creek, Coyote Creek, and San Gabriel River mainstem. None of the samples collected over two wet seasons exhibited acute or chronic toxicity. Dry weather samples were tested from 16 locations distributed throughout the lower watershed for up to 18 months. None of the dry weather samples from Walnut Creek, San Jose Creek, or the San Gabriel River mainstem exhibited acute or chronic toxicity. Acute and chronic toxicity was intermittently measured in the Coyote Creek tributary. Toxicity identification evaluations suggested nonpolar organic constituents, likely diazinon and perhaps surfactants, as possible toxicants. Toxicity observed in this study was significantly reduced compared to a similar study of the watershed 12 years previously, especially in the San Gabriel River mainstem. Much of the reduction in toxicity was associated with upgrades in WRP treatment. Little to no change in toxicity was observed in Coyote Creek upstream of the WRP discharge where little to no control of dry weather urban runoff had occurred.

Urban watersheds receive a multitude of potential pollutants that can affect aquatic life (Bay et al. 1996, Ackerman et al. 2005, Tiefenthaler and Stein 2005). The San Gabriel River, located on the border between Los Angeles and Orange Counties in southern California, is an ideal example of the ways in which aquatic life may be impacted by potential pollutants. Sources of potential pollutants include: 1) treated sanitary wastewaters from five Water Reclamation Plants (WRPs); 2) untreated urban runoff from approximately 350 km^2 of developed land discharged into the river via a municipal separate storm sewer system; and 3) once-through cooling waters from two power generating stations that is mixed with low volume industrial and sanitary wastes then discharged into the watershed's estuary.

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To complicate the fate and transport of anthropogenic pollutants and their resultant effects on aquatic life, the hydrology of many urban watersheds is often highly modified. For example, three major dams were constructed in the upper undeveloped reaches of the San Gabriel River watershed in order to capture, retain, and utilize wet season runoff for potable water use during the dry season. While this provides much needed water for the citizens of Los Angeles, the upper watershed is now hydrologically disconnected from the urbanized lower watershed. The result is that runoff from natural areas are unavailable for mixing and dispersion of anthropogenic discharges downstream. Even greater hydromodification exists in the urbanized lower San Gabriel River watershed. Many miles of the river in this portion of the watershed are lined with concrete in an effort to reduce flooding and property damage, but this modification also results in the maximum exposure of pollutants to aquatic life through the loss of natural stream and treatment processes. Where unlined channels exist in the lower watershed, temporary dams are inflated to enhance groundwater recharge.

In response to pollutant inputs and hydrologic modification, many urban watersheds have been the focus of water quality regulatory efforts. Urban Los Angeles once again provides a good example. More than 180 waterbodies in the Los Angeles region have been placed on the United States Environmental Protection Agency's (EPA's) list of impaired waters. This list, also referred to as the 303(d) list (referring to section 303 d of the Clean Water Act), identifies locations impacted by specific pollutants that can result in toxicity to aquatic life and other impacts. Virtually all of the urbanized portions of the San Gabriel River are one the 303(d) list for pollutants such as nutrients (and related impacts), certain trace metals, and aquatic toxicity. The effect of the 303(d) list is the mandate for future regulation (termed a total maximum daily load or TMDL), which will require the mitigation of these pollutant inputs.

In the San Gabriel River watershed, managers have been implementing mitigation to negate the effects of these pollutant inputs. Over the past 10 years, WRPs in the San Gabriel River watershed have installed additional treatment processes, costing over $40 million, that have dramatically improved the water quality of their discharges for nutrients and trace metals. Controlling pollutant impacts due to urban runoff has been more difficult. Up to $10 million has been spent on structural best management practices (BMPs) in the San Gabriel River, yet few (if any) trends in concentrations of toxic constituents monitored have been observed (LACDPW 2005). Unlike WRPs, urban runoff discharges are diffuse and, as a result, perhaps more difficult to treat and/or control.

The objective of this study was to evaluate the impact of pollutants on aquatic life in the highly urbanized lower watershed of the San Gabriel River. Impact to aquatic life was assessed through the use of toxicity testing. Four specific goals were identified: 1) assess the magnitude of toxicity at selected locations throughout the San Gabriel River watershed; 2) determine whether or not this magnitude changes seasonally; 3) if toxicity exists, identify the responsible toxicants; and 4) compare the magnitude of toxicity in this study to studies conducted historically in the San Gabriel River watershed to evaluate the effectiveness of watershed management actions.

Material and Methods

Toxicity in the San Gabriel River watershed was evaluated by separating the study into wet weather and dry weather components (Figure 1; Table 1). The wet weather component consisted of four sampling sites located at the downstream end of major

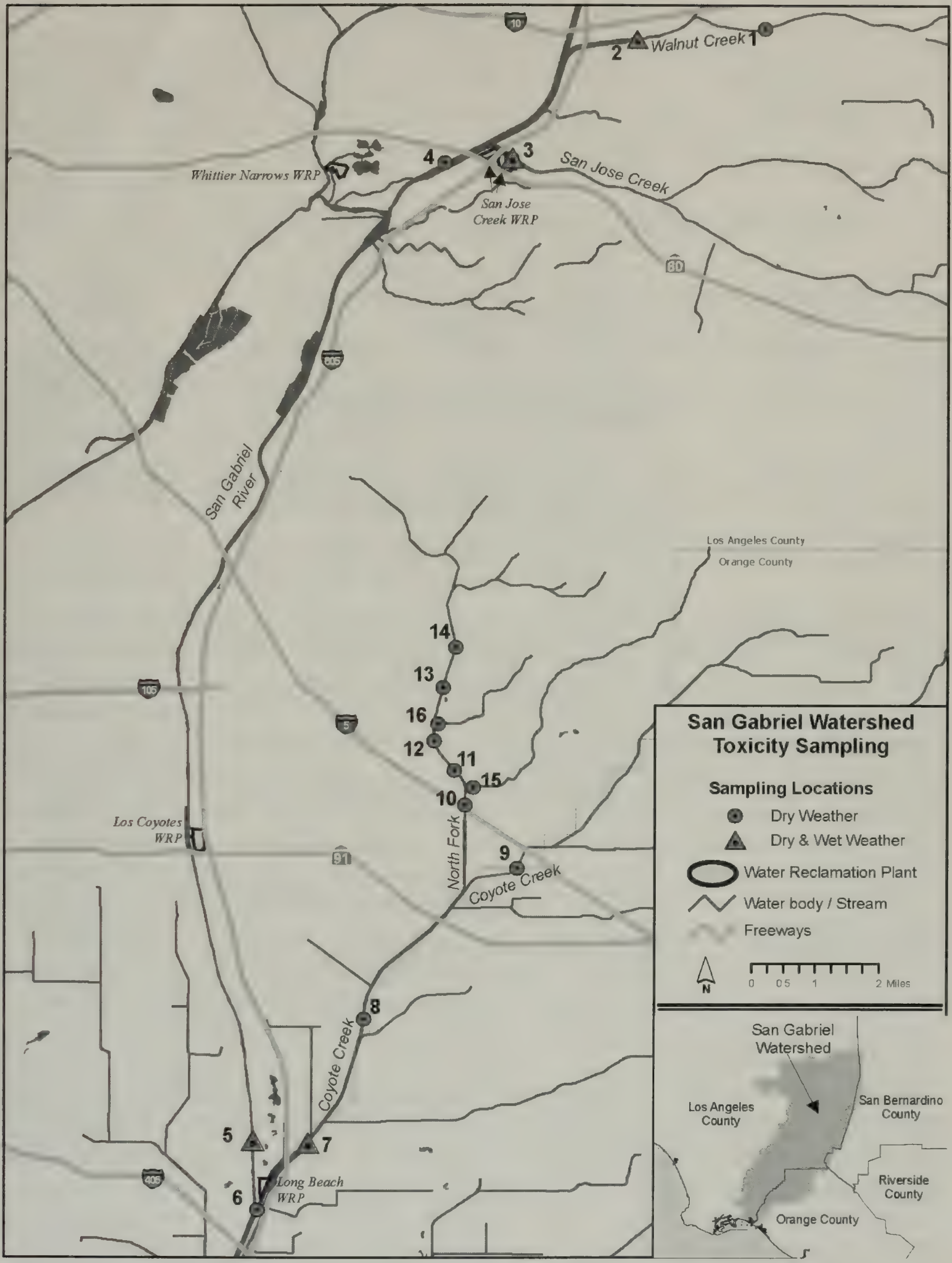
San Gabriel Watershed Toxicity Sampling
Sampling Locations
● Dry Weather
▲ Dry & Wet Weather
Water Reclamation Plant
Water body / Stream
Freeways
N
0 0.5 1 2 Miles
Walnut Creek
San Jose Creek
San Jose Creek WRP
Whittier Narrows WRP
San Gabriel River
Los Angeles County
Orange County
North Fork
Coyote Creek
Los Coyotes WRP
Long Beach WRP
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
10
605
105
5
91
405
60
San Gabriel Watershed
Los Angeles County
San Bernardino County
Riverside County
Orange County

Fig. 1. Map of the lower San Gabriel River Watershed including dry and wet weather sampling locations.

reaches that receive urban runoff. Twenty-liter flow weighted composites samples were collected during three storm events on December 29, 2004 (5.3 cm precipitation), April 22, 2005 (2.2 cm precipitation), and January 1, 2006 (3.7 cm precipitation). The dry weather component consisted of sampling a total of 10 sites that included the same four sites sampled during wet weather, plus an additional six sites strategically located in the

Table 1. Station location information (NAD83 datum).

Site #	Water Body	Location	Latitude Longitude
1	Walnut Creek	Walnut Creek At Merced Ave	N34°03′53.1″ W117°57′09.6″
2	Walnut Creek	At Baldwin Park Blvd	N34°03′47.7″ W117°58′54.5″
3	San Jose Creek Reach 1	San Jose Creek at access gate from SJCWRP/JAO – Upstream of SJCWRP, approximately 100 yards downstream of Workman Mill Rd	N34°02′06.7″ W118°01′14.9″
4	San Gabriel River Reach 3	San Gabriel River at Peck Rd - Downstream of confluence of SGR with SJC	N34°02′02.9″ W118°02′20.2″
5	San Gabriel River Reach 1	San Gabriel River at Spring St - Downstream of LCWRP outfall 001	N33°48′38.9″ W118°05′26.8″
6	Coyote Creek	Coyote Creek at pedestrian foot bridge south of LBWRP - Downstream of LBWRP outfall 001 and upstream of estuary	N33°47′41.9″ W118°05′22.0″
7	Coyote Creek	Coyote Creek at Cerritos Ave - Upstream of LBWRP outfall; downstream of entrance of Carbon Creek into Coyote Creek	N33°48′36.9″ W118°04′33.3″
8	Coyote Creek	Coyote Creek at Centralia Ave - Downstream of confluence with Fullerton Creek and an industrial drain	N33°50′19.3″ W118°03′37.9″
9	Coyote Creek	Coyote Creek at Artesia Blvd-Downstream of Brea Creek/Coyote Creek confluence	N33°52′23.7″ W118°01′08.0″
10	Coyote Creek (North Fork)	North fork of Coyote Creek at Alondra Blvd-Downstream of La Mirada Creek	N33°53′15.4″ W118°01′58.9″
11	Coyote Creek (North Fork)	Coyote Creek North Fork at La Mirada Creek/Coyote Creek confluence	N 33°53.731′ W 118°02.155′
12	Coyote Creek (North Fork)	Coyote Creek North Fork- 1.0 mile upstream of Alondra	N 33°54.133′ W 118°02.488′
13	Coyote Creek (North Fork)	Coyote Creek North Fork - 2.0 miles upstream of Alondra	N 33°54.862′ W 118°02.346′
14	Coyote Creek (North Fork)	Coyote Creek North Fork - 2.5 miles upstream of Alondra	N 33°55.411′ W 118°02.138′
15	La Mirada Creek	La Mirada Creek before entering Coyote Creek North Fork	N 33°53.503′ W 118°01.846′
16	Milan Creek	Milan Creek before entering Coyote Creek North Fork	N 33°54.369′ W 118°02.422′

immediate vicinity of WRP discharges or urban runoff inputs. Dry weather samples were collected at least three days after rain events. Twenty-liter samples were collected from each site during dry weather on a monthly basis from March 2005 to February 2006. Within seven months of this study's initiation, an additional six sites were added for dry weather sampling, all in a single tributary (North Coyote Creek), as a result of observed toxicity. All sites from the Coyote Creek subwatershed, including the additional sites in North Coyote Creek, were sampled until August 2006.

All samples were tested for toxicity using *Ceriodaphnia dubia* examining both acute (lethality) and chronic (reproductive success) endpoints. Testing was initiated within 36 hours of sample collection using undiluted sample and a negative control following standard US EPA protocols (US EPA 1993a; Table 2). Test organisms were obtained from in-house brood cultures and test duration/exposure lasted until 60% of the surviving females in the control had released three broods (typically between six and seven days). Test solutions were renewed daily.

Table 2. Test conditions and requirements.

Test Organism:	*Ceriodaphnia dubia*
Organism Source:	In-house Cultures
Organism Age at Initiation:	<24 hours old and released within an eight hour period
Test Duration:	Until 60% or ore of the surviving females have three broods
Concentrations Tested:	0% and 100%
Solution Renewal:	Daily
Feeding:	0.1 ml YCT and 0.1 *Selenastrum* algal suspension daily
Test Chamber:	50 ml Disposable
Solution Volume:	15 ml
Control Water:	Either diluted mineral water (8 parts deionized water: 2 parts Perrier® water) or Reconstituted deionized water (hard)
Number of Replicates:	10
Organisms per Replicate:	1 assigned by blocking by known parentage
Photoperiod:	16 hours light (50–100 ft-c), 8 hours dark
Test Temperature:	25 ± 1°C.
Endpoints Measured:	Survival and Reproduction
Test Acceptability Criteria:	80% or greater survival with an average of 15 or more young per surviving female in the control organisms. 60% of surviving females in the controls must produce three broods within 8 days.

Toxicity was defined as a 25%, or greater, organism response in the sample exposure relative to control organism response (i.e., <75% survival or reproduction in the 100% sample exposure). In addition, hypothesis testing was conducted following EPA guidelines (US EPA 1993a). Hypothesis testing consisted of the nonparametric Fisher's Exact Test for the survival endpoint and an analysis of variance (ANOVA) followed by a multiple comparison procedure for the reproduction endpoint. The parametric Dunnet's Test was used to identify statistically significant differences from the control for reproduction data that were normally distributed with homogeneous variances. The nonparametric Steel's Many-One Test was employed when the data failed normal distribution or equality of variance assumptions.

If a sample was toxic, a toxicity identification evaluation (TIE) was initiated (US EPA 1991, 1993b). TIE testing used the remaining sample, stored at 4°C, within seven days of baseline test conclusion. For those samples in which only the reproductive endpoint elicited a toxic response, only 100% and control concentrations were evaluated in the TIE. In these cases, the TIE consisted of a full seven-day chronic test with each sample manipulation consisting of 10 replicates, with daily renewals. For those samples where the survival endpoint elicited a toxic response, three dilutions (25%, 50%, 100%) and a control were evaluated using four replicates containing five test organisms each. In the case of a TIE in response to survival, the exposure duration was 96 hours, with renewal after 48 hours.

The TIE manipulations focused on both characterization and identification phases (EPA 1991, 1993b). These manipulations included: 1) pH adjustment; 2) aeration; 3) Ethylenedinitrilo-Tetraacetic Acid (EDTA); 4) Sodium thiosulfate (STS); 5) filtration; 6) piperonyl butoxide (PBO); 7) anion exchange column; 8) solid phase extraction (SPE); 9) SPE elution; and 10) no manipulation. By conducting each of these manipulations, the results, alone or in combination, can help to identify the responsible toxicant(s) (Table 3).

All quality assurance/quality control criteria were met for this study. These criteria included all of the test acceptability criteria (Table 2). In addition, positive control

Table 3. Toxicity Identification Evaluation (TIE) sample manipulations and their respective interpretations.

TIE Sample Manipulation	Expected response
pH Adjustment (pH 7 and 8.5)	Alters toxicity in pH sensitive compounds (i.e., ammonia and some trace metals)
Aeration	Reduces toxicity attributable to volatile, sublatable, and/or easily oxidizable compounds
Ethylenedinitrilo-Tetraacetic Acid (EDTA) Addition	Chelates trace metals, particularly divalent, cationic metals
Sodium thiosulfate (STS) Addition	Reduces toxicants attributable to oxidants (i.e., chlorine) and some trace metals
Filtration	Removes toxicity related to and/or associated with particulates
Solid Phase Extraction (SPE) with C_{18}	Removes toxicity associated with non-polar organics (i.e., pesticides, surfactants)
Sequential Solvent Extraction of with C_{18} Column	SPE extraction can be used to confirm toxicity due to nonpolar organic compounds. Sequential extraction using solvents of gradually decreasing polarity can separate these compounds into fractions providing further toxicant resolution and isolation for chemical analysis
Piperonyl Butoxide (PBO)	Removes toxicity caused by metabolically activated pesticides (i.e., organophosphorous pesticides). Increases toxicity attributable to pyrethroid pesticides
Anion Exchange	Removes toxicity associated with anionic compounds, including some trace metals and surfactants
No Manipulation	For comparing the relative effectiveness of other manipulations and quantifies the persistence of toxicity in the stored sample

samples using reference toxicants (copper chloride) confirmed the relative sensitivity and stability of test organisms during the course of the study.

Results

None of the storms sampled during this study were acutely or chronically toxic to *Ceriodaphnia*. At all four sites, during all three storms, survival and reproduction were greater than 75% relative to controls.

Eighteen of 196 (9%) total dry weather samples exhibited chronic toxicity during this study (Table 4). Twelve of 196 (6%) total dry weather samples exhibited acute toxicity during this study. All of the dry weather samples that exhibited acute toxicity also exhibited chronic toxicity. In only one case was statistically significant toxicity observed when the response was less than 25% relative to controls (Station 15, Jan 2006). This resulted from low control variability. Only once was toxicity greater than 25% relative to controls and not statistically significant (Station 15, Mar 2006). This resulted from large sample variability.

All observed toxicity during this study was from Coyote Creek (Table 4). No toxicity was observed in Walnut Creek, San Jose Creek, or San Gabriel River Reaches 1 or 3. Widespread toxicity in Coyote Creek was observed in April 2005. As a result, an additional six stations upstream were added between July and October 2005. Widespread toxicity was observed again in August 2005. Widespread toxicity was not observed again for the remaining 12 months (September 2005 to August 2006).

In the two events for which widespread toxicity was observed in Coyote Creek (April and August 2005), the toxicity appeared to originate in the upper portions of the tributary (Figure 2). In April 2005, 100% reproductive impairment was observed at the

Table 4. Summary of dry weather *Ceriodaphnia dubia* toxicity from San Gabriel River from March 2005 through August 2006.

	Month of Sample Collection																	
	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Location	2005	2005	2005	2005	2005	2005	2005	2005	2005	2005	2006	2006	2006	2006	2006	2006	2006	2006
Walnut Creek																		
1	-	-	-	-	-	-	-	-	-	-	-	-	-	▨	▨	▨	▨	▨
2	-	-	-	-	-	-	-	-	-	-	-	-	-	▨	▨	▨	▨	▨
San Jose Creek Reach 1																		
3	-	-	-	-	-	-	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
San Gabriel River Reach 3																		
4	-	-	-	-	-	-	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
San Gabriel River Reach 1																		
5	-	-	-	-	-	-	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
Coyote Creek																		
6	-	**S^1**	-	-	-	**L^{1}S^1**	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
7	-	**L^{1}S^1**	-	-	-	**L^{1}S^1**	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
8	-	**L^{1}S^1**	-	**S^1**	-	**L^{1}S^1**	-	-	-	-	-	-	▨	▨	▨	▨	▨	▨
9	**S^1**	-	-	-	-	-	**L^{1}S^1**	-	-	-	-	-	-	-	-	-	-	-
10	**S^1**	**L^{1}S^1**	-	**L^{1}S^1**	-	**L^{1}S^1**	-	-	-	-	-	-	-	-	-	-	-	-
11	▨	▨	▨	▨	-	**S^1**	-	-	-	-	-	-	-	-	-	-	-	-
12	▨	▨	▨	▨	-	**L^{1}S^1**	-	-	-	-	-	-	-	-	-	-	-	-
13	▨	▨	▨	▨	-	**L^{1}S^1**	-	-	-	-	-	-	-	-	-	-	-	-
14	▨	▨	▨	▨	-	**L^{1}S^1**	-	-	-	-	-	-	-	-	-	-	-	-
15	▨	▨	▨	▨	▨	▨	▨	-	-	**-**	**-^{1}**	-	**S**	-	-	-	-	-
16	▨	▨	▨	▨	▨	▨	▨	-	-	-	-	-	-	-	-	-	-	-

Shaded areas = samples not collected, "-" represents not toxic with effects less than 25% relative to control, L = Lethal, effect with toxicity less than 75% relative to control, S = Sub-lethal effect; reproduction less than 75% relative to control, "^{1}" = statistically significant from control.

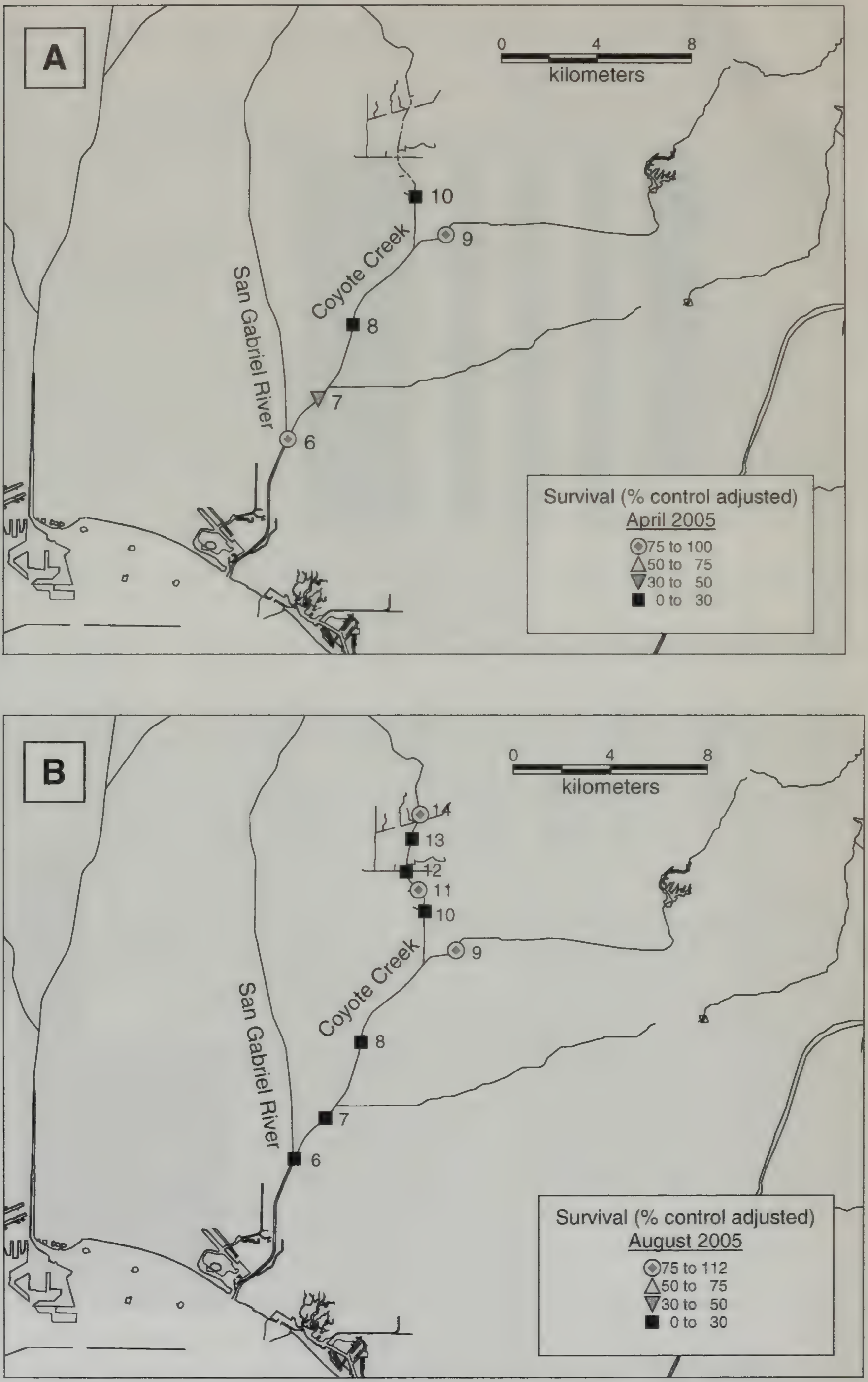
A
0
4
8
kilometers
10
9
Coyote Creek
San Gabriel River
8
7
6
Survival (% control adjusted)
April 2005
◈ 75 to 100
△ 50 to 75
▼ 30 to 50
■ 0 to 30
B
0
4
8
kilometers
14
13
12
11
10
9
Coyote Creek
San Gabriel River
8
7
6
Survival (% control adjusted)
August 2005
◈ 75 to 112
△ 50 to 75
▼ 30 to 50
■ 0 to 30

Fig. 2. Survival in Coyote Creek; A) April 2005; and B) August 2005.

Table 5. Summary of dry weather TIE results.

		TIE RESULTS (Survival in 100% Sample)										
Site #	Sample Date	No Manipulation	STS^{a}	EDTA^{b}	pH 7.0	pH 8.5	PBO^{c}	Aeration	Filtration	Centrifuge	SPE	Anion
9	Mar 2005	Sample No longer Toxic										
10	Mar 2005	Sample No longer Toxic										
10	Apr 2005	0%	0%	0%	0%	0%	0%^{d}	35%	0%	NT	87.5%^{e}	NT
10	Jun 2005	0%	0%	0%	0%	0%	0%	10%	10%	30%	100%^{e}	100%
10	Aug 2005	0%	0%	0%	0%	0%	0%	0%	0%	NT	100%^{e}	0%^{f}
9	Sep 2005	0%	0%	0%	0%	0%	100%^{g}	0%	0%	NT	100%^{e}	0%
15	Mar 2006	Sample No longer Toxic										

NT = Not tested

a–Sodium thiosulfate addition, two treatments of 10 and 25 ppm

b–Ethylenedinitrilo-tetraacetic acid addition, two treatments of 25 and 50 ppm

c–Piperonyl butoxide addition, two treatments of 50 and 100 ppb

d–5% survival observed in the 50 ppb treatment with 0% survival in the 100 ppb treatment

e–Toxicity recovered in only the 75% methanol elution

f–Survival observed in lower concentrations of the sample indicating partial toxicity removal

g–80% survival observed in 50 ppb treatment and 100% survival in 100 ppb treatment

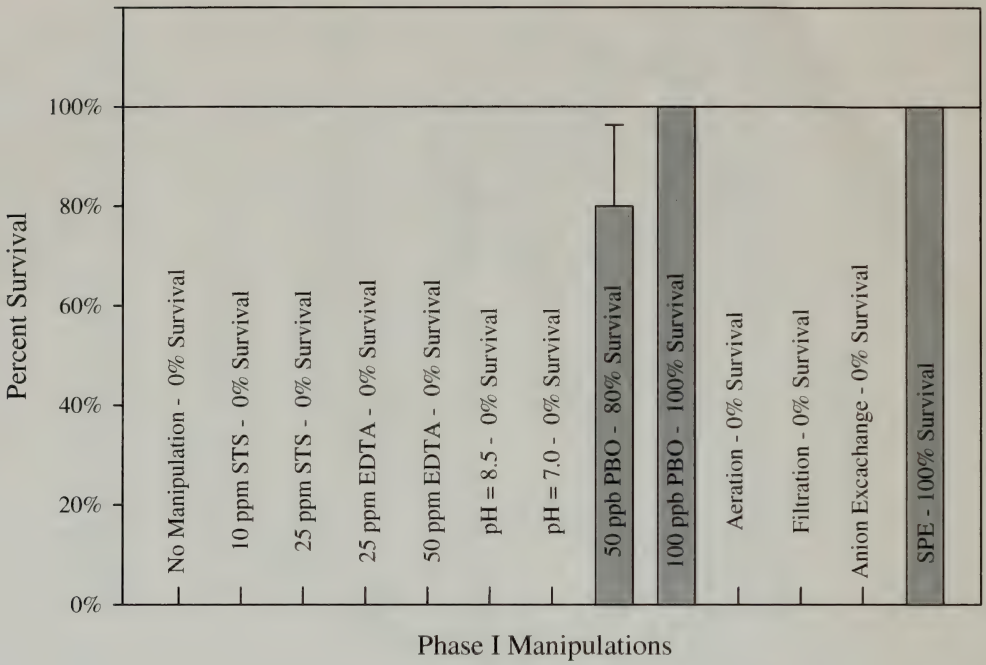

Fig. 3. Acute Phase I TIE - site 10 sample collected on April 21, 2005.

site sampled furthest upstream (site 10) and reproductive success remained minimal moving downstream. *Ceriodaphnia* survival was also severely impacted at the furthest upstream station, then survival slowly increased downstream of the WRP discharge (Sites 7 and 6) indicating a potential dilution effect from the WRP effluent. The WRP in this reach was discharging 13 mgd of effluent to Coyote Creek upstream of Site 6 during this sampling event. In August 2005, severe reproductive impairment was again observed at the site sampled furthest upstream (site 14) and reproductive success remained minimal moving downstream. The WRP in this reach was not discharging effluent to Coyote Creek during this sampling event. *Ceriodaphnia* survival was more sporadic moving downstream during August 2005. Seventy eight percent survival was measured at site 14 and decreased to 0% survival for downstream Sites 13 and 12. Survival increased to 100% at site 11, but fell back to 0% survival for the remaining seven miles of Coyote Creek. The sudden increase in survival at Site 11 remains unexplained.

Seven TIEs were initiated during the study on dry weather samples exhibiting a 25% or greater effect (Table 5). Toxicity was no longer present for three of the samples (sites 9 and 10 March 2005, site 15 March 2006);consequently, no toxicant was identified.

Organophosphorus pesticides, most likely diazinon, were identified as the causative agent in one sample (site 10 April 2005). This result was based on the exclusive removal of toxicity using SPE and the addition of PBO, which removes non-polar organic toxicants and inhibits toxicity due to diazinon, respectively (Figure 3). The SPE was sequentially eluted and these fractions were subsequently tested. Toxicity was recovered in the 80% methanol elution of the SPE column, a fraction associated with many organophosphorus pesticides including diazinon (Figure 4). Finally, 1,700 µg/L diazinon was quantified in the sample using Enzyme-Linked Immuno-Sorbant Assay (ELISA) techniques.

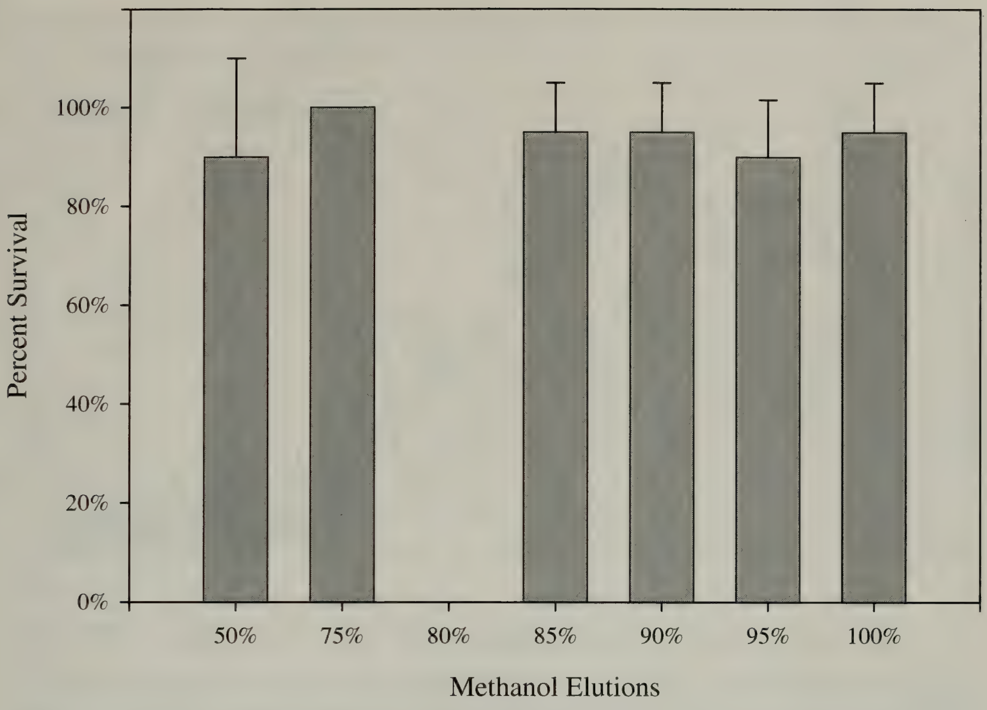

Fig. 4. Acute Phase I TIE Solid Phase Extraction Elution Testing - Site 10 sample collected on April 21, 2005.

A non-polar organic toxicant(s), possibly a surfactant(s), was identified as the causative agent in the remaining three samples (site 10 April, June, and August 2005). This result was based on the removal of toxicity using SPE. Toxicity was recovered in the 75% methanol elution, a fraction commonly associated with organophosphorus pesticides with surfactant toxicity recovery also documented (Norberg-King et al. 2005). An anion exchange column was used on two samples, with complete removal of toxicity observed in one sample (June 2005) and partial removal in the other (August 2005). This may be indicative of anionic surfactants, but might also suggest the presence of some trace metals. Elution of the anion column would help to confirm anionic surfactant toxicity, but attempts to recover toxicity from the anion column were not successful. However, other treatments to identify trace metals did not reduce toxicity (i.e., EDTA), which helps to rule-out metals as a major source of toxicity. Aeration partially removed toxicity in the April 2005 sample. Some surfactants can be removed or partially removed through aeration. Finally, PBO did not reduce toxicity, and levels of diazinon in these three samples were low (<100 µg/L).

Discussion

Toxicity was not widespread in the San Gabriel River watershed over the 18 months examined during this study. No toxicity was observed at any site during any of the storm events sampled. Similarly, no toxicity was observed in four of the five major reaches in the lower watershed during dry weather. In Coyote Creek where toxicity was observed, the toxicity was intermittent and occurred only during six of the 18 sampling periods. This was despite an adaptive monitoring strategy, in which the number of sites sampled in Coyote Creek was doubled and the sampling period was extended by six months.

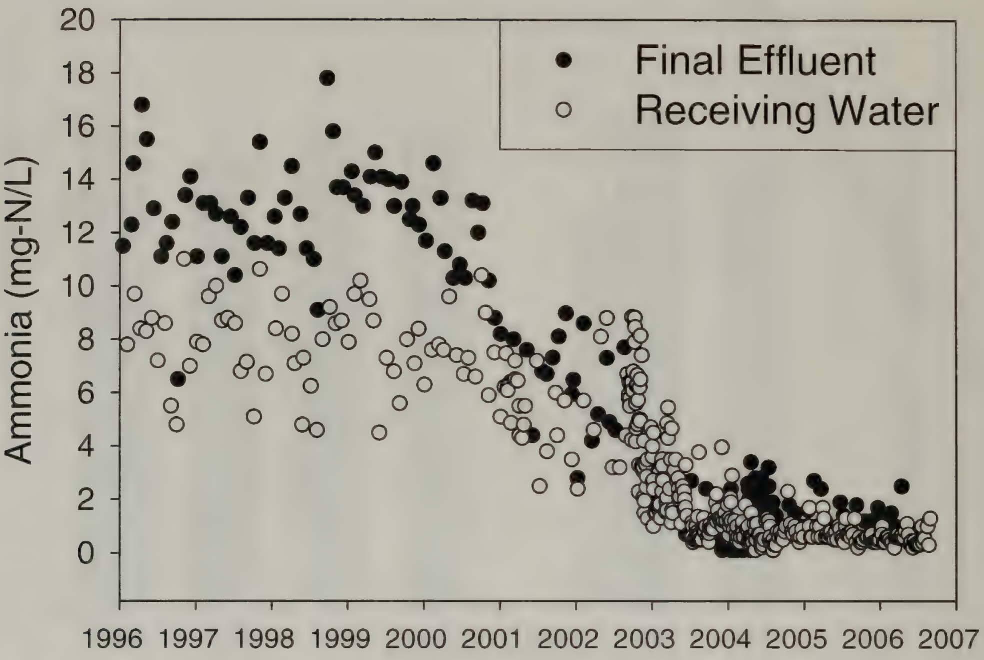

Fig. 5. Time series plot of ammonia concentrations in final effluent and receiving water immediately downstream of the Los Coyotes WRP in the lower San Gabriel River Watershed. NDN plant upgrades were completed in June 2003 (unpublished data, Los Angeles County Sanitation Districts).

The lack of toxicity observed in this study was in direct contrast to historical studies in this watershed. While 9% of the samples were toxic in 2005/06, 55% of the samples collected for a similar study in 1992/93 were toxic (Bailey et al. 1995). Moreover, toxicity was observed in only a single reach (Coyote Creek) in 2005/06, while Bailey et al. (1995) identified toxicity in all five major reaches in the lower San Gabriel River watershed.

The difference in toxicity from tests conducted 14 years ago is likely due to changes in water quality. Bailey et al. (1995) concluded that toxicity in the San Gabriel River watershed was likely due to non-polar organics and possibly ammonia. This is not unexpected as there are multiple WRPs discharging to the San Gabriel River; these treated effluent discharges comprise roughly 80% of flow during the dry season, contributing as much as 99% of the total ammonia input (Ackerman et al., 2005). In 1992/93, ammonia levels averaged over 10 mg/L. In 2003, however, the WRPs fully implemented nitrification and denitrification treatment (NDN) processes, which subsequently reduced discharged ammonia levels more than 80% to an average of less than 2 mg/L (Figure 5). Thus, a reduction in toxicity for reaches in the San Gabriel River watershed dominated by WRP effluents can be easily explained.

The lack of toxicity observed in the current study is consistent with other toxicity data collected in recent years. In 2005, a probability-based watershed survey was conducted in the entire San Gabriel River watershed, and 7% of the stream-miles were considered toxic to *Ceriodaphnia* (Stein and Bernstein, in prep). Even this toxicity, however, was eliminated after a TIE and subsequent follow-up investigations helped identify and eliminate the illicit discharge responsible.

A second example of reduced toxicity in recent years was observed in routine toxicity monitoring required in the vicinity of the WRPs as a part of their National Pollutant

Discharge Elimination System (NPDES) permit requirements. Between June 2003 and June 2006, only 14% of the 269 total samples from 14 different sites exhibited toxicity (i.e., greater than 25% response relative to controls). For this period, toxicity was largely constrained to Coyote Creek (6% of total number of samples) and the uppermost portions of San Jose Creek (6% of total number of samples). Coyote Creek is the same tributary in which the current study found intermittent toxicity. The uppermost section of San Jose Creek was not monitored during the current study.

In contrast to the main stem of the San Gabriel River, much less effort has been spent on identifying and remediating sources of toxic pollutants in the Coyote Creek subwatershed. As a result, the toxicity in Coyote Creek has remained. The frequency of toxicity in Coyote Creek has remained similar between 1992/93 and 2004/05; roughly 12% to 22% of the samples were considered toxic. Pesticides available for application by homeowners continue to be one toxicant of concern. Diazinon was identified in 2004/05 (this study), as well as in the 1992/93 study (Bailey et al. 1995). The toxicity observed in urban runoff-dominated reaches during this study was intermittent, which is consistent with contributions by homeowner pesticide use (Schiff and Tiefenthaler 2003), illegal/illicit discharges, and observations in other dry weather runoff toxicity studies (Greenstein et al. 2004).

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References

Ackerman, Drew, E.D. Stein, and K.C. Schiff. 2005. Dry-season water quality in the San Gabriel River watershed. Bull So Cal Acad of Sci, 104:125–145.

Bailey, H., A. Villalobos, E. Gottl, L. Brattin, D. Hanes, and D. Hinton. 1995. Site specific study for effluent dominated streams (San Gabriel River, Santa Clara River, Calleguas Creek). Prepared for the California Regional Water Quality Control Board, Los Angeles Region. University of California, Davis, Davis, CA.

Bay, S.M., D.J. Greenstein, S-L. Lau, M.K. Stenstrom, and C.G. Kelley. 1996. Toxicity of dry weather flow from the Santa Monica Bay Watershed. Bull So Cal Acad of Sci, 95:33–45.

Brown, J. and S. Bay. 2003. Organophosphorus pesticides in the Malibu Creek watershed. Technical Report 403. Southern California Coastal Water Research Project. Westminster, CA.

Greenstein, Darrin J., L. Tiefenthaler, and S. Bay. 2004. Toxicity of parking lot runoff after application of simulated rainfall. Env Contam and Tox, 47:199–206.

LACDPW. 2005. Los Angeles County 1994–2005 integrated receiving water impact report. Los Angeles County Department of Public Works, Alhambra, CA.

Norberg-King, T.J., L.W. Ausley, D.T. Burton, W.L. Goodfellow, J.L. Miller, and W.T. Waller. 2005. Toxicity reduction and toxicity identification evaluations for effluents, ambient waters, and other aqueous media. Society of Environmental Toxicology and Chemistry (SETAC) Press, Pensacola, FL.

Schiff, K. and L. Tiefenthaler. 2003. Contributions of organophosphorus pesticides from residential land uses during dry and wet weather. Technical Report 406. Southern California Coastal Water Research Project. Westminster, CA.

Stein, Eric D. and L.L. Tiefenthaler. 2005. Dry-weather metals and bacteria loading in an arid, urban watershed: Ballona Creek, California. Water, Air, and Soil Pollution, 164:367–382.

US EPA. 1991. Methods for aquatic toxicity identification evaluation: Phase I toxicity characterization procedures, Second Edition. EPA 600/6-91/003. US Environmental Protection Agency, Environmental Research Laboratory, Duluth, MN.

US EPA. 1993a. Methods for measuring acute toxicity of effluents and receiving waters to freshwater and marine organisms, Fourth Edition. EPA 600/4-90/027. US Environmental Protection Agency, Environmental Research Laboratory, Duluth, MN.

US EPA. 1993b. Methods for aquatic toxicity identification evaluation: Phase II toxicity identification procedures for acute and chronic toxicity, Second Edition. EPA 600/R-92/080. US Environmental Protection Agency, Environmental Research Laboratory, Duluth, MN.

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Post-Impingement Survival and Inferred Maximum Thermal Tolerances for Common Nearshore Marine Fish Species of Southern California

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Abstract.—The effectiveness of a pilot post-impingement fish return program was studied at Los Angeles Department of Water and Power's Scattergood Generating Station during six heat treatments from February 2005 to August 2006. Species-specific total percent survival was computed for all individuals impinged, with an overall survival of 0.4% across all species impinged during monitored heat treatments, ranging from 30.2% for *Paralabrax clathratus* to 0.0% for *Seriphus politus*. Species-specific critical thermal maxima was inferred from surveys of the abundances returned by San Onofre Nuclear Generating Station's highly effective and unique Fish Return System during heat treatments from 2000–2005. Abundant species such as queenfish exhibited low thermal thresholds (15–20°C), while spotfin croaker and barred sand bass became stressed at higher temperatures (25–30°C).

One potential pathway to reduce impingement mortality at generating stations utilizing once through cooling water systems is to return live fish back to the ocean. In southern California, this would be especially useful during heat treatments, during which ambient water temperatures within the cooling water system are raised past 38°C, exceeding the critical thermal maximum for all nearshore marine fish common to the Southern California Bight. At nearly all generating stations within southern California, the most logistically feasible recovery technique is to recover live fish impinged upon the traveling screens used to filter cooling water.

Heat treatments are an operational procedure periodically conducted to control the growth of biofouling organisms that settle out on the walls of the intake conduits (Graham et al. 1977). These growths can restrict water flow to levels that may cause substantial operational and maintenance problems up to, and including, shutting down the station (Graham et al. 1977). These authors determined that water temperatures maintained at greater than 40°C for nearly one hour achieved 100% mortality among biofouling organisms. They further reported that heat treatment duration was inversely proportional to maximum water temperature necessary to achieve better than 95% mortality of the biofouling organisms. Lastly, they concluded that minimal environmental impacts to nearby marine resources (fish populations, water quality, etc.) were produced by short, high temperature (> 40°C) heat treatments rather than longer, lower temperature treatments. At many coastal southern California generating stations with enclosed forebays this procedure can result in a substantial portion of the total annual impingement mortality.

Studies of survival of juvenile and adult marine organisms after entrapment in once through cooling water systems have largely been limited to the physical stress caused by impingement alone on Atlantic and Gulf Coast species (King et al. 1977, Muessig et al.

1988, McLaren and Tuttle 2000), with limited attention to the associated stressors of elevated water temperatures. Much of the work conducted on Pacific species was done at San Onofre Nuclear Generating Station (SONGS) in San Clemente, California, in relation to the operation of their novel fish return system (Love et al. 1989). The SONGS fish return system (FRS) limits the physical stressors encountered by the entrapped organisms by providing a return mechanism without interacting with the traveling screens, effectively eliminating impingement for those organisms that were routed through the FRS. While proving an effective means of reducing the impingement mortality, its applicability to existing once through cooling water systems is limited due to high costs and engineering constraints. SONGS Units 2 and 3 were initially constructed with the fish return system integrated into the overall design (R. H. Moore, MBC Applied Environmental Sciences, personal communication). Continued monitoring of the FRS immediately preceding heat treatments provided baseline insight into the thermal tolerances of various fish species common to the Southern California Bight.

This pilot study investigated the applicability of collecting live fish from the traveling screens at Scattergood Generating Station in Los Angeles, California during heat treatments as a potential means of reducing impingement mortality. Furthermore, critical thermal maxima for common coastal marine species were inferred based on analyses of SONGS FRS surveys.

Materials and Methods

Post-Impingement Survival

During routine monitoring of six heat treatments from February 2005 to August 2006 at Scattergood Generating Station (SGS), live fish were collected from traveling screens. Traveling screens at SGS are steel, 9.5-mm square mesh, which are continuously rotated during heat treatments. Housings for the traveling screens at Units 1 and 2 were opened, allowing for visual inspection and collection of animals off of the traveling screens. The housings at Unit 3, however, were sealed leaving the traveling screens relatively inaccessible. All traveling screens were 1.8-m wide and extended 7.2-m below ground level into the forebay.

Collections began at the start of the heat treatment when forebay water temperatures were at ambient levels and concluded when temperatures exceeded 35°C, as reported by generating station staff. Fish were collected by hand from the screens. After being removed from the traveling screen, all fish were held in buckets that had been filled with seawater prior to the start of the heat treatment. After the heat treatment concluded, all live fish were transported to the SEA Lab and transferred to holding tanks on a flow-through seawater system held at ambient conditions.

The SEA Lab maintained collected fish at their facility in Redondo Beach, California. Daily observations were made to determine the health (live or dead) of each collected organism per 24-hour time block for 144-hrs beyond the day of collection. Mortalities were recorded per 24-hr block. Abundances for total collected, daily mortality, total survival, and total impinged were reported by species (and fish family). Percent survival was derived for both the individuals collected and the total impinged abundance for each species and cumulatively across all species. Species-specific analysis was limited to those with greater than 100 individuals impinged during the course of the study. Although lengths were recorded for the recovered individuals, they could not be assigned to specific mortalities, as fish were not marked for identification.

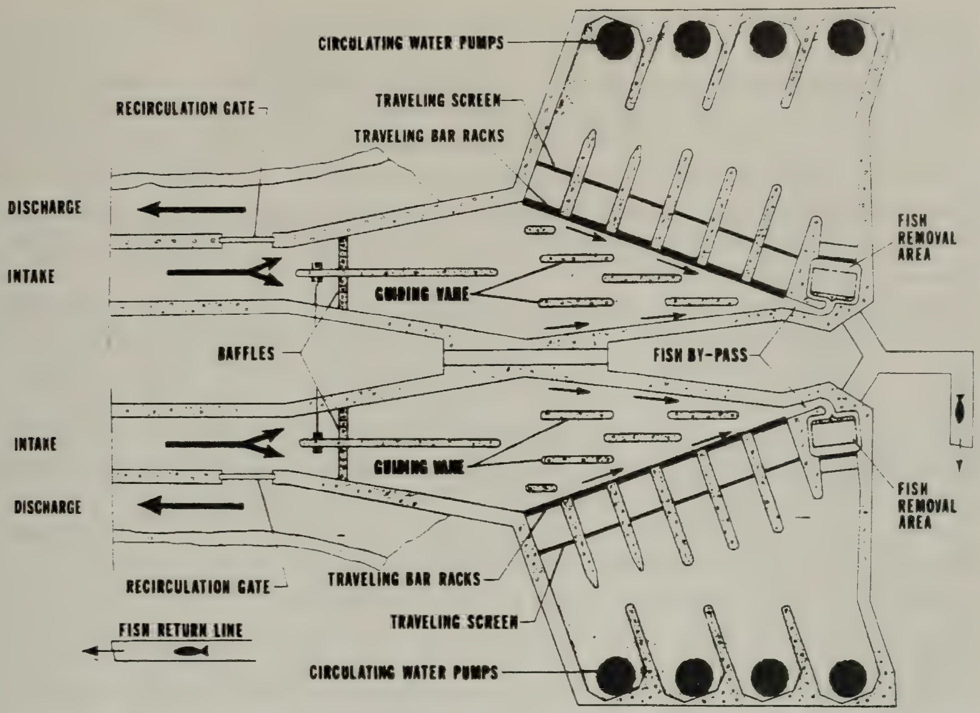
CIRCULATING WATER PUMPS
RECIRCULATION GATE
TRAVELING SCREEN
TRAVELING BAR RACKS
DISCHARGE
INTAKE
GUIDING VANE
FISH REMOVAL AREA
BAFFLES
FISH BY-PASS
INTAKE
GUIDING VANE
DISCHARGE
FISH REMOVAL AREA
RECIRCULATION GATE
TRAVELING BAR RACKS
TRAVELING SCREEN
FISH RETURN LINE
CIRCULATING WATER PUMPS

Fig. 1. San Onofre Nuclear Generating Station forebay depicting fish removal area (Fish Return System).

Inferred Critical Thermal Maxima

Operational procedures at SONGS for heat treatments include the "fish chase", which was designed to usher living fish within the forebay into a holding area where they can be lifted out and deposited into a dedicated discharge line (Figure 1). The design of the forebay for the FRS included guiding vanes that, in concert with the angled traveling screens, created a pressure differential that can be detected by the fish and ultimately direct them to the fish removal area (Love et al. 1989). This was accomplished by slowly raising the forebay water temperature while biologists monitor the FRS. Although it was expected that thermal gradients exist throughout the forebay as water temperature was raised, it was assumed that no areas of relatively cool water were present in which fish may find refuge. It was believed that the strong, unidirectional flow created by the circulating water pumps sufficiently mixed the waters within the forebay to greatly limit the extent of cool water refuges.

As fish became stressed due to the increased water temperature, their ability to swim against the cooling water flow diminished, increasing their likelihood of collecting in the fish removal area (Figure 1). The relative abundance and observed health of fish within the FRS elevator served as a behavioral indicator of inferred critical thermal maxima. Fish were lifted out of the SONGS forebay by a steel tray elevator system that raised the fish in a large pool of water up to a point at which they were deposited in a discharge flume filled with seawater at the ambient temperature of the coastal waters. Prior to depositing the fish, each elevator lift was visually inspected, organisms identified, and estimated abundance recorded. The procedure was continued until no live fish were present within the elevator. A more thorough description of the FRS is available in Love et al. (1989).

Recorded abundance, by species, per forebay water temperature, was reviewed for the period 2000–2005. Forebay water temperature was continuously recorded in the station control room from sensors located within the cooling water intake system. Data across all years was pooled and forebay water temperature rounded to the nearest integer. The percentage of the total abundance by species was derived for each temperature interval, with the 20 most abundant species examined. Data for the 15 most abundant species observed between 2000–2005 in the SONGS data set was included in the analysis. Similarities in species-specific responses to increasing water temperature were graphically derived through hierarchical clustering analysis. Proportional abundance by temperature block was used to calculate the inter-entity distance (dissimilarity) matrix. Euclidean distance (Clifford and Stephenson 1975) was used as the measure of dissimilarity. A cluster diagram was drawn based on these dissimilarities. Species groups were assigned to each unique cluster. Proportional abundance per species group was derived and plotted against their representative temperature block. Pearson product correlation was used to test the relationship between the forebay water temperature and the proportional abundance for each species group defined by cluster analysis.

During three heat treatments at SGS in 2005 (16 February, 6 April, 13 June) water temperature within the forebay was continuously monitored with a data logger positioned at the seaward edge of the forebay. This side of the forebay was subjected to warmer water temperatures prior to the rest of the forebay, due to its closer proximity to the intake/discharge tunnel openings. Circulation patterns and temperature mixing within the forebay was not measured. It was assumed that hydrodynamic forces previously described for the SONGS forebay were mixing the seawater in the SGS forebay. Deposition of impinged fish into the northwest basket was sampled every five minutes. Sampling consisted of filtering the effluent stream with a one-quarter inch mesh dipnet for one minute. Abundance per time interval was recorded and later plotted against water temperature profiles as reported by the data logger.

Results

Fish Return Program

A total of 464 individual fish, or 0.5% of all impinged fish, were collected alive representing 38 species from 19 families during six heat treatments monitored at SGS (Table 1). During these heat treatments, a total of 101,122 individual fish were impinged. Queenfish (*Seriphus politus*) was the most frequently observed species during the six impingement surveys, overall, with 31,957 individuals. Three additional species collected alive were represented by greater than 3,000 impinged individuals, including 5,525 topsmelt (*Atherinops affinis*), 4,380 white croaker (*Genyonemus lineatus*), and 3,721 walleye surfperch (*Hyperprosopon aregenteum*).

Walleye surfperch (58 individuals) was the most abundant species collected alive. In addition, 48 topsmelt, 45 kelp bass (*Paralabrax clathratus*), 44 bat rays (*Myliobatis californica*), and 30 black perch (*Embiotoca jacksoni*) were collected alive during impingement sampling (Table 1). Less than 30 individuals were collected alive from each of the remaining species. Of these, only topsmelt and walleye surfperch were included among the five most abundant impinged species overall.

Of the fish collected during the six heat treatments and held for observation, a total of 383, or 82.5%, survived the holding period, which equates to 0.4% of all impinged fish

Table 1. Hourly survival of fish species collected during heat treatments at Scattergood Generating Station, February 2005 to August 2006.

Species	Number Collected	Mortality per Hour Interval Since Collection							Total Survival	% Survival	Total Impinged	% Total Survival	% of Total Imp. Collected
		0	24	48	72	96	120	144					
Hyperprosopon argenteum	58	4	1	2	-	-	1	-	50	86.2	3,721	1.3	1.6
Atherinops affinis	48	1	3	-	-	-	-	-	44	91.7	5,525	0.8	0.9
Paralabrax clathratus	45	-	-	-	-	-	-	-	45	100.0	149	30.2	30.2
Myliobatis californica	44	15	-	2	-	-	-	-	27	61.4	164	16.5	26.8
Embiotoca jacksoni	30	2	1	-	-	-	-	-	27	90.0	175	15.4	17.1
Genyonemus lineatus	26	2	1	1	-	-	-	-	22	84.6	4,380	0.5	0.6
Atherinopsis californiensis	26	2	-	1	-	-	-	1	22	84.6	930	2.4	2.8
Pleuronichthys ritteri	21	2	2	1	-	-	-	-	16	76.2	100	16.0	21.0
Platyrhinoidis triseriata	19	-	2	-	1	-	-	-	16	84.2	38	42.1	50.0
Urobatis halleri	18	-	-	-	-	-	-	-	18	100.0	52	34.6	34.6
Paralabrax nebulifer	14	1	-	-	-	-	-	-	13	92.9	156	8.3	9.0
Scorpaena guttata	13	-	-	-	-	-	-	-	13	100.0	77	16.9	16.9
Seriphus politus	11	7	3	-	-	-	-	-	1	9.1	31,957	0.0	0.0
Rhacochilus toxotes	11	-	-	1	1	-	-	1	8	72.7	68	11.8	16.2
Sebastes auriculatus	10	-	-	-	-	-	-	-	10	100.0	44	22.7	22.7
Chromis punctipinnis	7	-	-	-	-	-	-	-	7	100.0	131	5.3	5.3
Cheilotrema saturnum	7	-	1	-	-	-	-	-	6	85.7	91	6.6	7.7
Hypsoblennius gilberti	7	-	-	-	-	1	1	-	5	71.4	48	10.4	14.6
Medialuna californiensis	6	1	1	-	-	-	-	-	4	66.7	16	25.0	37.5
Cymatogaster aggregata	5	2	-	-	-	-	-	-	3	60.0	428	0.7	1.2
Atherinopsidae	5	1	1	1	-	1	1	-	-	0.0	266	0.0	1.9
Atractoscion nobilis	5	-	-	-	-	-	-	-	5	100.0	23	21.7	21.7
Heterostichus rostratus	5	-	-	-	-	-	-	-	5	100.0	22	22.7	22.7
Paralichthys californicus	4	1	-	-	-	-	1	-	2	50.0	13	15.4	30.8
Menticirrhus undulatus	3	-	-	-	-	-	-	1	2	66.7	62	3.2	4.8
Scorpaenichthys marmoratus	3	-	-	-	-	1	-	-	2	66.7	4	50.0	75.0
Oxyjulis californica	2	-	-	-	-	-	-	-	2	100.0	21	9.5	9.5
Phanerodon furcatus	1	-	-	-	-	-	-	1	-	0.0	158	0.0	0.6
Rhacochilus vacca	1	-	-	-	-	-	-	-	1	100.0	20	5.0	5.0
Sebastes paucispinis	1	-	-	-	-	-	-	-	1	100.0	16	6.3	6.3
Brachyistius frenatus	1	-	-	-	-	-	-	-	1	100.0	6	16.7	16.7
Oxylebius pictus	1	-	1	-	-	-	-	-	-	0.0	4	0.0	25.0
Torpedo californica	1	-	-	-	-	-	-	-	1	100.0	2	50.0	50.0
Parophrys vetulus	1	-	-	-	-	-	-	-	1	100.0	1	100.0	100.0
Pleuronichthys guttulatus	1	-	-	-	-	-	-	-	1	100.0	1	100.0	100.0
Sebastes atrovirens	1	-	1	-	-	-	-	-	-	0.0	1	0.0	100.0
Sebastes chrysomelas	1	-	-	-	-	-	-	-	1	100.0	1	100.0	100.0
Stereolepis gigas	1	-	-	-	-	-	-	-	1	100.0	1	100.0	100.0
Total all species	464	41	18	9	2	3	4	4	383	82.5	101,122	0.4	0.5

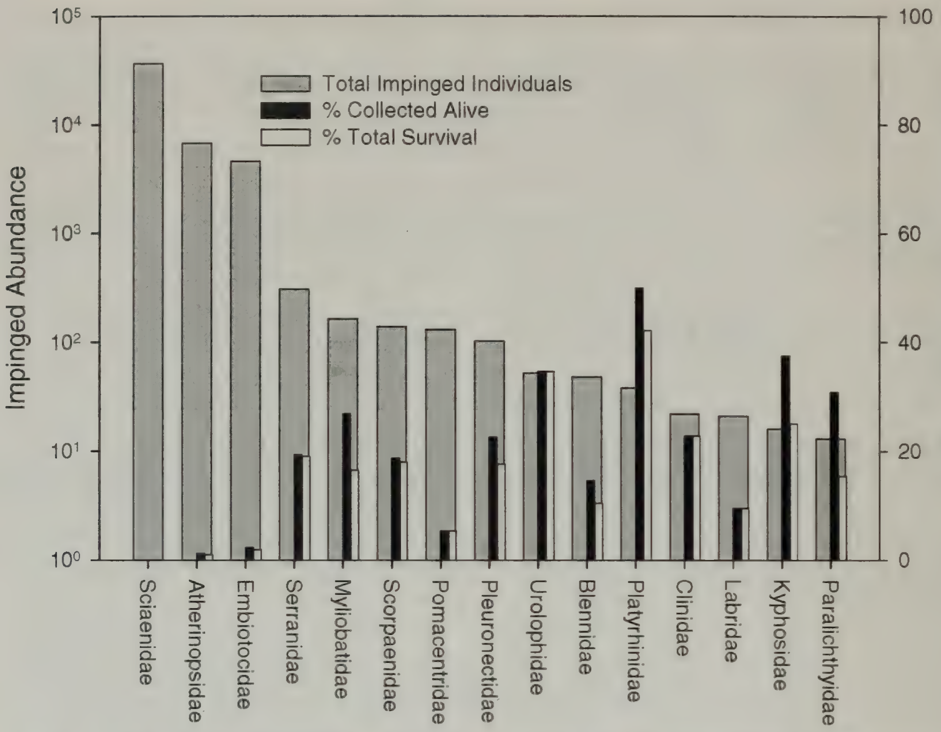

Fig. 2. Log of impinged abundance, total percent collected alive, and total percent survival during heat treatments by fish family observed at Scattergood Generating Station.

(Table 1). Survival of individuals from species with a minimum of 100 individuals impinged was highly variable. Overall survival was generally inversely proportional to total impingement. The highest overall survival rate was recorded for kelp bass, with 30.2% survival, or 45 individuals surviving out of 149 individuals impinged. Other species that exhibited relatively strong heat treatment survival patterns include bat ray (16.5%), spotted turbot (*Pleuronichthys ritteri*) (16.0%), and black perch (15.4%), but all three species were impinged in relatively low abundances, each less than 0.2% of the total impinged abundance. Five additional species survived in proportions ranging from 1.0 to 10.0% of their species-specific impinged abundance.

Three fish families (Embiotocidae, Atherinopsidae, and Sciaenidae) represented the majority of all impinged fish (Figure 2). Highly abundant families exhibited little to no survival, while less abundant families were more influenced by the recovery efforts. Occasionally, there was considerable intra-familiar variation, such as with sciaenids. Virtually all queenfish and white croaker perished over the course of the heat treatment. A greater proportion of California corbina (*Menticirrhus undulatus*) survived through the holding period, while greater than one-fifth of all impinged white sea bass (*Atractoscion nobilis*) survived. Each of the latter two species was infrequently impinged, represented by a total of 62 and 23 individuals, respectively (Table 1).

Analyses of the collected individuals illustrate the various species-specific, post-impingement latent survivability. Latent post-impingement survival for the 15 species with 10, or greater, individuals collected alive ranged from 9.1% for queenfish to 100% for four species, including kelp bass, round stingray (*Urobatis halleri*), California

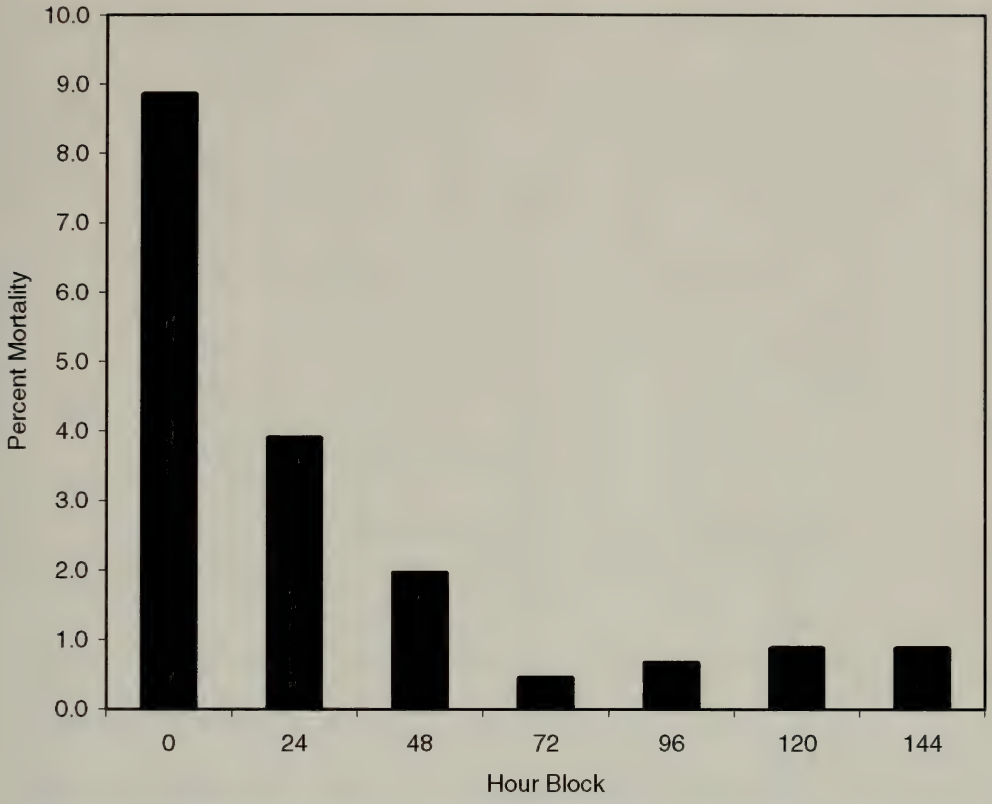

Fig. 3. Percent mortality by hour block for fishes collected during heat treatments at Scattergood Generating Station.

scorpionfish (*Scorpaena guttata*), and brown rockfish (*Sebastes auriculatus*) (Table 1). For the collected individuals, peak mortality occurred within the first 48-hrs, with nearly 9% perishing within the first 24-hrs (Figure 3). This figure was greatly influenced by the high mortality of bat rays, followed by nearly 70% of all queenfish perishing within the first 24-hrs (Table 1). The overall survivability of queenfish was poor, with one out of 11 individuals collected surviving the holding period. Overall, 11 out of 15 species with greater than 10 individuals collected exhibited greater than 80% latent survival rates.

Inferred Critical Thermal Maxima

The principle stressor on fishes observed during heat treatments was the forebay water temperature (designed to exceed 38°C), which interferes with the metabolic processes of most fish (Helfman et al. 1997). Although all fishes entrapped within the enclosed forebay were subjected to these conditions, notable differences have been observed with regards to their varying thermal tolerances. Species-specific abundance within the FRS elevator was indicative of the relative composition of the entrapped assemblage, as it has been anecdotally noted that various species arrive in the elevator area in sequential stages related to water temperature (R. H. Moore, MBC Applied Environmental Sciences, personal communication).

Fish abundance by 1°C temperature interval illustrates a wide-ranging distribution among the 29 most abundant species over the period 2000–2005 (Table 2). Of these, the

Table 2. Proportional abundance by 1° C temperature block for the 20 most abundant species observed at SONGS FRS, 2000–2005.

	Forebay Water Temperature (C)																				
Species	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	38
Anisotremus davidsonii	-	0.6	0.4	0.1	4.5	4.3	1.5	3.1	1.4	3.1	2.2	8.6	10.0	8.1	7.7	13.1	17.8	12.2	1.1	0.1	0.2
Atherinops affinis	-	47.5	19.7	0.3	7.6	7.7	6.7	2.6	0.9	1.5	2.5	0.5	0.3	1.4	0.7	-	0.2	-	-	-	-
Atherinopsis californiensis	0.2	2.1	50.3	6.0	3.7	6.2	15.7	4.5	0.3	4.8	0.7	2.6	1.3	0.7	0.6	0.2	0.1	0.1	-	-	-
Cheilotrema saturnum	-	-	-	-	2.2	3.7	-	2.2	20.6	2.9	0.7	-	2.2	4.4	7.4	14.0	19.1	19.9	0.7	-	-
Embiotoca jacksoni	-	-	3.7	6.8	2.1	15.3	-	3.7	0.5	4.2	1.6	7.9	14.7	6.3	13.2	11.6	7.4	1.1	-	-	-
Engraulis mordax	0.1	1.7	10.9	1.0	6.5	20.3	3.5	21.5	7.1	17.1	4.5	2.8	1.8	1.0	0.2	0.1	0.0	0.0	-	-	-
Genyonemus lineatus	-	-	50.6	3.7	8.3	13.1	5.9	1.5	-	6.4	-	0.2	0.1	5.0	4.7	0.6	-	-	-	-	-
Hermosilla azurea	-	0.5	-	-	-	1.0	0.1	1.2	2.1	3.3	-	5.5	8.5	2.0	12.5	14.2	29.9	18.5	-	-	0.8
Hyperprosopon argenteum	0.9	1.3	26.9	6.0	5.3	5.3	8.2	3.6	1.1	11.5	2.7	6.5	15.6	3.8	0.9	0.3	0.3	-	-	-	-
Paralabrax clathratus	-	-	-	-	0.6	3.6	1.2	4.8	2.4	5.4	3.6	1.2	13.8	13.8	18.6	14.4	10.2	3.0	3.6	-	-
Paralabrax nebulifer	-	-	1.4	0.5	1.5	0.7	0.7	1.6	1.8	3.1	2.1	4.0	8.1	8.8	19.8	14.3	16.8	11.9	2.8	0.1	-
Peprilus simillimus	-	-	67.9	3.4	8.1	0.2	0.2	11.7	-	2.7	0.8	2.9	1.7	-	0.5	-	-	-	-	-	-
Phanerodon furcatus	-	10.2	5.1	5.4	0.3	13.9	1.0	3.1	1.0	17.3	10.5	16.0	2.0	7.5	4.4	-	2.0	-	-	-	-
Roncador stearnsii	-	0.1	0.0	0.2	1.1	5.4	1.1	0.7	0.2	3.9	0.3	2.5	14.7	41.9	11.6	9.1	6.1	1.2	-	-	-
Sardinops sagax	-	12.4	13.7	28.9	12.9	11.3	13.6	0.5	1.0	1.6	1.6	1.2	0.6	0.3	0.3	0.1	0.2	-	-	-	-
Scorpaena guttata	0.9	-	2.8	4.7	1.9	2.8	1.9	0.9	5.7	14.2	0.9	8.5	15.1	13.2	12.3	5.7	4.7	3.8	-	-	-
Seriphus politus	1.0	2.6	36.9	12.9	8.6	10.4	1.7	8.9	1.8	9.4	1.7	1.9	1.2	0.3	0.5	0.4	0.0	0.0	-	-	-
Trachurus symmetricus	-	-	-	-	-	37.0	18.3	4.6	0.7	16.7	3.1	11.2	1.9	0.7	2.3	-	1.1	2.1	0.4	-	-
Umbrina roncador	-	0.1	0.5	0.3	3.0	3.2	1.4	2.7	2.8	5.1	1.9	7.0	17.0	12.4	15.0	10.3	9.0	7.3	0.6	0.2	0.1
Xenistius californiensis	-	9.0	1.5	0.2	1.4	3.2	6.5	6.9	8.4	5.9	4.4	6.6	21.8	7.3	4.7	2.2	6.9	2.8	0.3	-	-

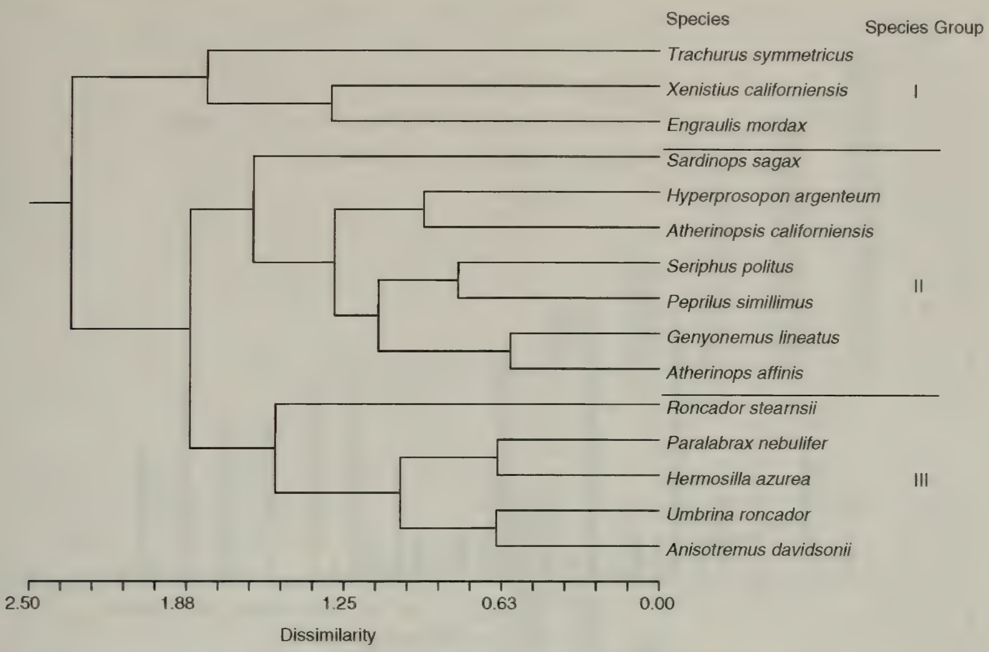
Species
Species Group
Trachurus symmetricus
Xenistius californiensis
Engraulis mordax
I
Sardinops sagax
Hyperprosopon argenteum
Atherinopsis californiensis
Seriphus politus
Peprilus simillimus
II
Genyonemus lineatus
Atherinops affinis
Roncador stearnsii
Paralabrax nebulifer
Hermosilla azurea
III
Umbrina roncador
Anisotremus davidsonii
2.50
1.88
1.25
0.63
0.00
Dissimilarity

Fig. 4. Results of the cluster analysis for the fifteen most abundant species observed during FRS surveys at SONGS, 2000–2005, based on proportional abundance and forebay water temperature relationships.

relationship between the 15 most abundant species by the forebay water temperature-elevator abundance interaction was visualized through cluster analysis (Figure 4). Based on the dissimilarity coefficients, three species groups were delineated. Group I includes jack mackerel (*Trachurus symmetricus*), salema (*Xenistius californiensis*), and northern anchovy (*Engraulis mordax*) that were relatively cosmopolitan with regards to the relationship of temperature and abundance (Figure 5) and showed no direct correlation to forebay water temperature ($r = 0.41$, $p = 0.07$). The proportional abundances of Group I species peaked at 20°C. Group II included many of the more abundant species observed in impingement surveys across the Southern California Bight (MBC 2005a, MBC 2005b), including queenfish, walleye surfperch, jacksmelt (*Atherinopsis californiensis*), Pacific sardine (*Sardinops sagax*), Pacific pompano (*Peprilus simillimus*), white croaker, and topsmelt (Figure 4). Proportional abundances for Group II species peaked at 15°C (Figure 5) and exhibited a significant correlation with temperature ($r = 0.57$, $p < 0.01$).

Species with higher critical thermal maxima comprised Group III, namely zebraperch (*Hermosilla azurea*), spotfin croaker (*Roncador stearnsii*), barred sand bass (*Paralabrax nebulifer*), yellowfin croaker (*Umbrina roncador*), and sargo (*Anisotremus davidsonii*) (Figure 4). Proportional abundances were consistently higher between 25°C and 30°C than at the remaining temperatures (Figure 5). Group III did not exhibit a significant correlation with water temperature ($r = 0.36$, $p = 0.11$).

Although relative thermal tolerances, based on the SONGS FRS data, was consistent within most fish families, e.g. Serranidae, Embiotocidae, etc., some substantial variation was present within select families, most notably the sciaenids (Table 2). Queenfish and white croaker both reached their respective peak abundances at 15°C while yellowfin

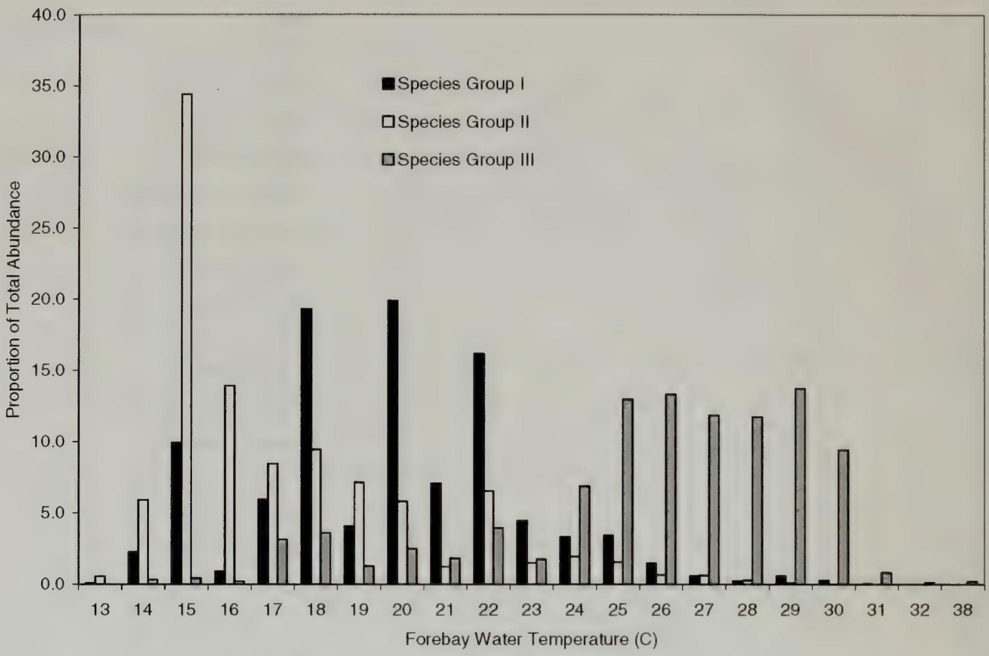

Fig. 5. Total proportional abundance by forebay water temperature for each species group observed during FRS surveys at SONGS, 2000–2005.

croaker and spotfin croaker proportional abundances peaked at 25°C and 26°C, respectively.

In sampling designed to emulate the SONGS fish chase, three heat treatments were monitored for total fish abundance by temperature block at SGS (Figure 6). Abundances of impinged fish nearly doubled on each survey after the forebay water temperatures reached 29°C, as recorded by the data logger. Queenfish and topsmelt comprised the majority of each sample during these heat treatments.

Discussion

Heat treatments at southern California power plants with enclosed forebays contribute a substantial portion of the total impingement mortality recorded. As a part of their efforts to examine ways of reducing fish impingement mortality, a pilot fish return program was evaluated at SGS. The pilot program indicated an overall low survival, with only 0.4% of all fishes impinged during the monitored heat treatments surviving the 144-hr holding period. Furthermore, these data suggest the overall efficacy of this type of return program was highly species-specific. Hearty species such as kelp bass exhibited higher survivorship over the holding period, which corresponded to a 30.2% reduction in their species-specific impingement mortality, while less hearty species, such as queenfish, rarely survived the holding period.

Mortality among all collected species during the holding period was highest within the first 24-hrs after being impinged, before declining rapidly to the 72-hr block, where mortality reached a low of 0.4%, and remained below 1.0% for the remainder of the holding period. Generally, fish species with greater maximum thermal tolerances, such as kelp bass, were collected alive in proportionally greater abundances. These species individually represented less than 0.2% of the total impingement. Of those species

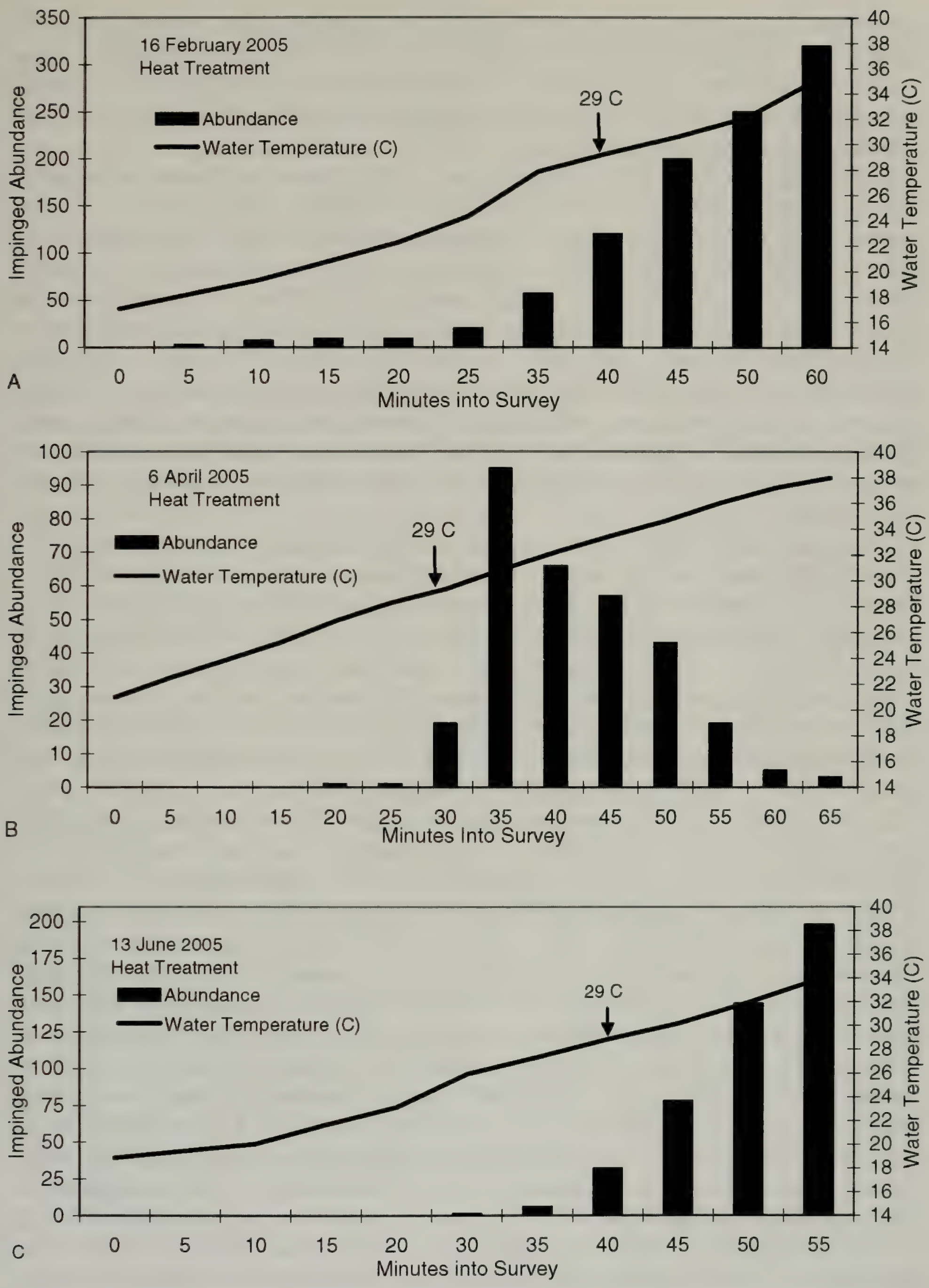

Fig. 6. Impinged abundance and forebay water temperature for three heat treatments at SGS, A) 16 February 2005, B) 6 April 2005, C) 13 June 2005.

representing greater than 1.0% of the total impinged abundance, only four were collected alive off the traveling screens at SGS. Walleye surfperch was the only member of this group that exhibited greater than 1.0% overall survival. Queenfish was the most abundant species impinged, but less than 0.1% were collected alive and less than 10% of those collected alive survived the holding period.

At SONGS, the FRS provided insight as to the thermal tolerances of common nearshore marine fish. Exact values for critical thermal maxima (CTM) and lethal temperature (LT) could not be directly quantified with the FRS due to the design of the forebay at SONGS, which precludes observations consistent with previous studies of thermal tolerance in fish (Tsuchida 1995, Rajaguru 2002). Typical studies determine the CTM by the fish loss of righting response (LRR), which is typified by an observable loss of equilibrium. The construction of the forebay at SONGS precludes this. In contrast, this study examined the abundances of fishes that were presumably stressed by the heated water within the forebay and subsequently concentrated in the fish removal area. Additionally, the LT cannot be fully quantified because moribund fishes at SONGS are frequently collected by the traveling screen structures rather than collecting in the fish removal area.

Cluster analysis of the 15 most frequently observed species in the SONGS FRS revealed three groups, with definitive intra-family variation, based on their proportional abundances by temperature. The highly abundant species with biogeographic ranges that extend into the Oregonian Province (Love et al. 2005, Horn et al. 2006) principally comprised Groups I and II, exemplifying their affinity for cooler water with higher proportional abundances at lesser forebay water temperatures and near absences at the higher temperatures. Meanwhile, Group III species, which were principally San Diegan Province species (Love et al. 2005, Horn et al. 2006), exhibited substantially greater maximum thermal tolerances during the FRS surveys.

The abundance to forebay water temperature relationship observed during three SGS heat treatments indicates dramatically increased abundances at temperatures less than 29°C. During these surveys at SGS, queenfish was the most abundant species, followed by topsmelt, both of which were included in FRS Group II. Based on the FRS analyses, both species have similar cooler water affinities and inferred critical thermal maxima of approximately 15°C, which is consistent with the marked increases in impinged abundance observed circa 29°C at SGS. The exact temperature at which the fish were overcome at SGS was undetermined due to the size and volume of the forebay. This was further confounded by the variable time required for a fish to be carried out of the forebay by the traveling screens, washed along the collection trough, and finally deposited in the sampling basket. These variables all contribute to the unreliability in determining the critical thermal maxima, based on SGS data, but does confirm that water temperatures within a range preceding 29°C was incapacitating for the entrapped fish, namely queenfish and topsmelt.

The SGS fish return program did carry inherent variables that could not be completely accounted for, namely handling stress and injury resulting from physical impingement upon the traveling screen and physiological stress resulting from heating the surrounding seawater in excess of 38°C. The handling stress was unaccounted for, and may have been considerable, but the physiological stress was partially addressed by the associated analysis of the SONGS FRS surveys. It was assumed, but untested, that the stresses caused by handling may exceed those that may be experienced in transit through a dedicated return conduit, similar to that which was used at SONGS.

Love et al. (1989) examined the survivorship of fish returned to the ocean at ambient temperature via the FRS at SONGS Units 2 and 3. During these trials fish were diverted into a net holding pen moored on the seafloor upon exiting from the return conduit. A reference station to determine experimental variation was constructed by corralling fish into a similar net pen located near the return conduit off San Onofre. One significant difference between Love et al. (1989) and the current investigation was the added handling and impingement stress each animal encountered in the current study that was not present during the SONGS experiments. During the SONGS studies water temperatures were maintained at ambient levels as the FRS was operated, thereby removing the physiological stress of the heated water as well as the handling/impingement stress. Fish were held in their respective net pens *in situ* for 96-hrs to test for latent mortality.

Northern anchovy was the most abundant species in the Love et al. (1989) study, exhibiting relatively high survival rates for both units, but none were colleted alive during the current study at SGS, despite substantial impinged abundances. Queenfish was the second most abundant species included in the Love et al. (1989) study. In their experimental treatments, they recorded 31.6 and 54.1% survival for queenfish discharged by the SONGS Units 2 and 3 FRS, respectively, while 78.8% of the reference site individuals survived. These values were substantially higher than was recorded during the current investigation, which can be attributed to the increased stressors encountered by queenfish in the current study. The physical trauma caused by impingement, in addition to the elevated water temperatures may have worked in concert to greatly reduce impingement survivability, as indicated by the relatively low percentage of impinged individuals that were collected alive. Although individual fish were not identified so as to coordinate fish lengths and survivability in the SGS study, high survival variability in relation to fish size was observed in queenfish by Love et al. (1989).

White croakers were also collected in high enough abundances during the SONGS study to warrant further analysis (Love et al. 1989). The authors reported latent survival rates for white croaker similar to that of queenfish, 49.5% for Unit 2 and 25.0% for Unit 3. The latent survival for individuals collected alive in the current study exceeded that reported by Love et al. (1989), with 84.6% of all individuals collected alive surviving the holding period, but with substantially smaller sample sizes than those used by Love et al. (1989). In the previous SONGS study, 93% and 39% (1984 and 1985, respectively) of all white croaker entrapped in the cooling water system were returned alive by the FRS while less than 1% of those impinged at SGS were collected alive. Despite the differences in latent survival, these data indicate that substantially more white croaker were returned to the coastal waters alive by SONGS than was possible at SGS.

Overall, the latent survivability observed in the current study compares favorably to the prior study at SONGS, although the overall entrapment survival was greatly reduced at SGS. During the study at SONGS, a minimum of 75.1% of all annually entrapped fish was returned to the nearshore waters. Three of the species directly analyzed; northern anchovy, queenfish, and white croaker, were returned in highly variable percentages (Love et al. 1989). During the current study, approximately 0.4% of the fishes entrapped in the cooling water system at SGS survived through the holding period. Although not all fish returned at SONGS survived, the associated survival data indicated well above 50% of all individuals, for most species, survived the encounter.

No other studies of fish survival at coastal power plants have been published in southern California, but work has been published from the Atlantic Coast. King et al.

(1977) examined the survival of adult Atlantic tomcod (*Microgadus tomcod*) at ambient temperature at Roseton and Danskammer Point Generating Stations located along the Hudson River. Their studies determined proportionally high survivorship among impinged individuals. Initial survival ranged from 89 to 96% at both stations, while latent survival after an 84-hr holding period ranged from 71 to 86%. The researchers further noted that impingement survival was greatest among fishes collected while the traveling screens were in continuous operation, with inversely proportional increases in mortality as the length of time the screens remained stationary increased.

Muessig et al. (1988) conducted similar studies at Bowline Point and Danskammer Point Generating Stations, also located on the Hudson River. They observed a wider range of impinged species, and noted a relatively high initial impingement survival of greater than 80%. Latent survival of impinged individuals varied widely, with several highly abundant species exhibiting better than 50% survivorship, while alewives (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*) displayed very high mortality rates after a four-day holding period. Neither King et al. (1977) or Muessig et al. (1988) incorporated high water temperatures, as would occur during heat treatments, in their study design. It is unknown what effect, if any, increased water temperatures may have on the overall survivability of these test species, although it is assumed the increased stress would increase the overall mortality.

A similar lack of relevant data was available regarding thermal tolerances for marine fishes common to the Southern California Bight. Ehrlich et al. (1979) examined thermal behavioral responses in several commonly impinged fish species. Although it should be noted that most of the species included in this analysis were among those that exhibited higher survival rates during the current SGS fish return study. They found that adult black perch immediately searched out an area in their test tank with a mean water temperature of 18°C, which is well below the inferred critical thermal maxima estimated at approximately 25°C. Further similarity between the current study and Ehrlich et al. (1979) was noted for black croaker (*Cheilotrema saturnum*), with both studies suggesting a relatively high thermal tolerance.

Finally, the traumas induced during the heat treatment procedure impart substantial stress to the fish, which cannot be overcome for the most highly abundant species. Therefore, the results of the post-impingement return program at SGS, especially in comparison to the effective FRS at SONGS, suggests this was an ineffective method, providing little protection for common nearshore marine fishes of southern California. The current investigation indicates that the physical and physiological stresses must be limited, such as what is accomplished by the operation of the SONGS FRS, in order to measurably reduce the overall impingement mortality, as illustrated by the difference in the survival of entrapped anchovies during each study. Unfortunately, no known technologies exist that were able to meet these goals without endangering the station's ability to meet their power generation demands. As was noted previously, the SONGS FRS was designed into the original construction plans. Retrofitting the SGS forebay to include a similar FRS would require nearly insurmountable construction elements such as a dedicated return conduit, elevator, and guiding vanes, all of which work in concert to make the SONGS FRS effective.

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Literature Cited

Clifford, H.T. and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, New York. 229 pp.

Ehrlich, K.F., J.M. Hood, G. Muszynski, and G.E. McGowen. 1979. Thermal behavioral responses of selected California littoral fishes. Fish. Bull., 76:837–849.

Graham, J.W., J.N. Stock, and P.H. Benson. 1977. Further Studies on the Use of Heat Treatment to Control Biofouling in Seawater Cooling Systems. Oceans, 77:23A-1–6.

Helfman, G.S., B.B. Collette, and D.E. Facey. 1997. Diversity of Fishes. Blackwell Science, Inc., Malden, MA. 528 pp.

Horn, M.H., L.G. Allen, and R.N. Lea. 2006. Biogeography. Pp. 3–25 *in* The Ecology of Marine Fishes: California and Adjacent Waters. (L.G. Allen, D.J. Pondella, II., and M.H. Horn, eds.), Univ. California Press, 660 pp.

King, L.R., J.B. Hutchinson, Jr., and T.G. Huggins. 1977. Impingement survival studies on white perch, striped bass, and Atlantic tomcod at three Hudson River Power Plants. Pp. 217–233 *in* Fourth National Workshop on Entrainment and Impingement. (L.D. Jensen, ed.). EA Communications, Melville, NY.

Love, M.S., M. Sandhu, J. Stein, K.T. Herbinson, R.H. Moore, M. Mullin, and J.S. Stephens, Jr. 1989. Analysis of fish diversion efficiency and survivorship in the fish return system at San Onofre Nuclear Generating Station. NOAA Technical Report NMFS 76. 15 pp.

———, C.W. Mecklenburg, T.A. Mecklenburg, and L.K. Thorsteinson. 2005. Resource Inventory of Marine and Estuarine Fishes of the West Coast and Alaska: A Checklist of North Pacific and Arctic Ocean Species from Baja California to the Alaska–Yukon Border. U. S. Department of the Interior, U. S. Geological Survey, Biological Resources Division, Seattle, Washington, 98104, OCS Study MMS 2005-030 and USGS/NBII 2005-001.

MBC Applied Environmental Sciences. 2005a. National Pollutant Discharge Elimination System 2005 Receiving Water Monitoring Report. El Segundo and Scattergood Generating Stations, Los Angeles County, California. Prepared for Los Angeles Dept. of Water and Power, 111 North Hope Street, Los Angeles, CA 90012 and El Segundo Power L.L.C. 62 p. plus appendices.

MBC Applied Environmental Sciences. 2005b. National Pollutant Discharge Elimination System 2005 Fish Impingement Monitoring Report. AES Huntington Beach L.L.C. Generating Station, Orange County, California. Annual Report. Prepared for AES Huntington Beach L.L.C, Huntington Beach, CA. 18 p. plus appendices.

McLaren, J.B. and L.R. Tuttle. 2000. Fish survival on fine mesh traveling screens. Env. Sci. Pol., 3: S369–S376.

Muessig, P.H., J.B. Hutchinson, Jr., L.R. King, R.J. Ligotino, and M. Daley. 1988. Survival of fishes after impingement on traveling screens at Hudson River Power Plants. Pp. 170–182 *in* Science, Law, and Hudson River Power Plants. (L.W. Barnthouse, R.J. Klauda, D.S. Vaughn, and R.L. Kendall, eds.), American Fisheries Society Monograph 4, Bethesda, MD.

Rajaguru, S. 2002. Critical thermal maximum of seven estuarine fishes. J. Thermal Biology., 27:125–128.

Tsuchida, S. 1995. The relationship between upper temperature tolerance and final preferendum of Japanese marine fish. J. Thermal Biology., 20:35–41.

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Habitat Partitioning by Two Sympatric Species of Chipmunk (Genus: *Neotamias*) in the Warner Mountains of California

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Abstract.—In the Warner Mountains of California, two sympatric species of chipmunk partition their habitat primarily through the mechanism of competitive exclusion by social dominance and aggressive interactions. Forests are optimal habitats for both *Neotamias amoenus* and *N. minimus*. In this study *N. amoenus* actively excludes *N. minimus* from the forest through successful aggressive interspecific interactions, leaving N. *minimus* to occupy primarily the arid sagebrush scrub. *Neotamias amoenus* was observed to be the more social species. *Neotamias minimus* appears to lack the level of social structure of *N. amoenus* and was not observed to win any aggressive encounters. *Neotamias minimus* avoids interaction with *N. amoenus*.

It is generally accepted that two species cannot occupy the same area, utilizing the same resources during the same time (Savage 1958; Whittaker et al. 1973). The question then arises as to how can two or more closely related species occupy the same locality. Competitive exclusion is a mechanism that has been proposed to explain the utilization of the same area by two similar species (Brown 1971; Connell 1961). Competitive exclusion is the exclusion of one species by another from mutually desirable resources (Armstrong and McGehee 1980). One species can exclude another from a resource through a variety of mechanisms that may include social and physical dominance. Although dominance is usually discussed within a particular species, the same principles can apply to interspecific interactions between morphologically similar species (Morse 1974).

Chipmunks (genus *Neotamias*) are ecologically diverse rodents that can be found in a wide array of habitats across North America. Most species are contiguously allopatric and actively partition common habitat areas (Heller 1971). A number of species may share a relatively small area, but distributions tend only to be abutting with overlapping ranges kept to a minimum (Patterson 1980). Chipmunks achieve nearly non-overlapping ranges through various mechanisms of competitive exclusion such as aggression (Brown 1971; Chappel 1978; Meredith 1976; Sheppard 1971) and avoidance (Morse 1974; Sheppard 1971). The importance of interspecific dominance, as a mechanism of habitat partitioning, through interspecific aggression between chipmunk species has been supported and well documented by Brown (1971), Chappell (1978) Heller (1971), Meredith (1976), Sheppard (1971), and others. For example, it has been documented that in a laboratory setting *N. amoenus* is dominant over *N. minimus* through aggressive interactions (Sheppard 1971; Meredith 1976).

Neotamias minimus is the most widely distributed of all North American chipmunks and occupies a wide spectrum of habitats such as sagebrush scrub, woodland, and alpine scrub (Sheppard 1971, Hall 1981, Bergstrom 1992, Verts & Carraway 2001). *Neotamias amoenus*, although less widespread than *N. minimus*, can be found abundantly throughout open brush and dense forests in the Pacific Northwest, Idaho, Montana, and Wyoming (Hall 1981, Sheppard 1971, Meredith 1976, Sutton 1992). In the Warner Mountains of northeastern California, *N. amoenus* can be found primarily in the conifer forests, while *N. minimus* predominately occupies the sagebrush scrub, with both species being abundant in an intermediate ecotonal area containing a relatively even mixture of conifers and sagebrush. It was in this overlapping intermediate area that a unique opportunity was available to observe frequent interspecific interactions between these two species and to test the hypothesis of competitive exclusion through aggressive dominance by *N. amoenus*.

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This study addressed the question of how *N. amoenus* and *N. minimus* partition their habitat in the Warner Mountains, Modoc County, California. Based on the results of previous studies (Brown 1971, Chappell 1978, Heller 1971, Meredith 1976, and Sheppard 1971) it is hypothesized that competitive exclusion through interspecific aggression and avoidance may be the mechanisms by which these two species partition their habitat.

Materials and Methods

Study Site

All data were collected from a single site in the Warner Mountains, Modoc National Forest, Modoc County, California. The site was located approximately 13 km East of Blue Lake Campground at an elevation of 2105 meters above sea level (N 41° 11′, W 120° 14′).

The study site consisted of three habitats: coniferous forest, sagebrush scrub, and an area of ecotone between the two. The conifer forest community is an area dominated by lodgepole pine (*Pinus contorta*), Jeffrey pine (*Pinus jeffreyi*), and white fir (*Abies concolor*). Ground cover consisted of grasses, forbs, mule ears (*Wyethia helenioides*), yellow bush lupine (*Lupinus arboreus*) and indian paintbrush (*Castilleja coccinea*). The sagebrush scrub community contained mostly big sagebrush (*Artemisia tridentata*) with only a few scattered conifers. The intermediate (ecotonal) community was defined as an area with a mixture of both big sagebrush and conifers.

Species Identification

Although these two chipmunks closely resemble one another, they are distinguishable on the basis of several characteristics. *Neotamias minimus* has an average total length of 167–225 mm, average tail length of 70–114 mm, and an average weight of 32–50 g (Verts and Carraway 2001). *Neotamias amoenus* has an average total body length of 186–238 mm, average tail length of 72–109 mm, and an average body weight of 36–50 g (Sutton 1992). In this study (N = 179), *N. amoenus* and *N. minimus* ranged in actual observed weight from 39–59 g (n = 117) and 31–56 g (n = 62), respectively.

The major differences that make them distinguishable in the field are that *N. minimus* is generally smaller and paler than *N. amoenus* with the fur located on the underside of the tail being more yellowish, the rostrum being shorter, and having a tawny tuft of fur at the base of the ear. *Neotamias amoenus* is in turn distinguishable from *N. minimus* by not having the above features and having a more reddish under-tail and broader, lighter dorsal stripes (Hall, 1981; Kays and Wilson, 2002). Male and female individuals could not be distinguished in the field.

Habitat Utilization

Chipmunk utilization of the three habitats was determined by live trapping. One hundred folding aluminum Sherman live traps (7.6 × 9.0 × 23.4 cm) with galvanized steel doors were placed in a 190 × 90 m grid. The grid consisted of ten trap-lines placed 20 m apart with ten traps per line set 10 m apart. The grid was oriented so that the trap-lines ran northeast to southwest. Each of the four corners was marked with an aluminum stake for the duration of the study. Each of the 100 traps was flagged and sequentially numbered (1 to 100) starting in the forest. The grid was placed so that each habitat type was sampled. The conifer forest and sagebrush scrub contained three trap lines each, while the ecotone area contained four (Figure 1).

A total of thirteen days of trapping was conducted (three each in July and September, and seven in August). Traps were baited using a combination of oats, dried fruit, raw almonds, and raw sunflower seeds. Traps were set at 0700 hrs and checked and closed by 1000 hrs. Captured animals were identified to species and gender, ear tagged with a numbered monel small animal ear tag and weighed. Any significant conditions such as obvious pregnancy, lactation, or scrotal distention were recorded. The animals were then released.

Behavioral Interactions

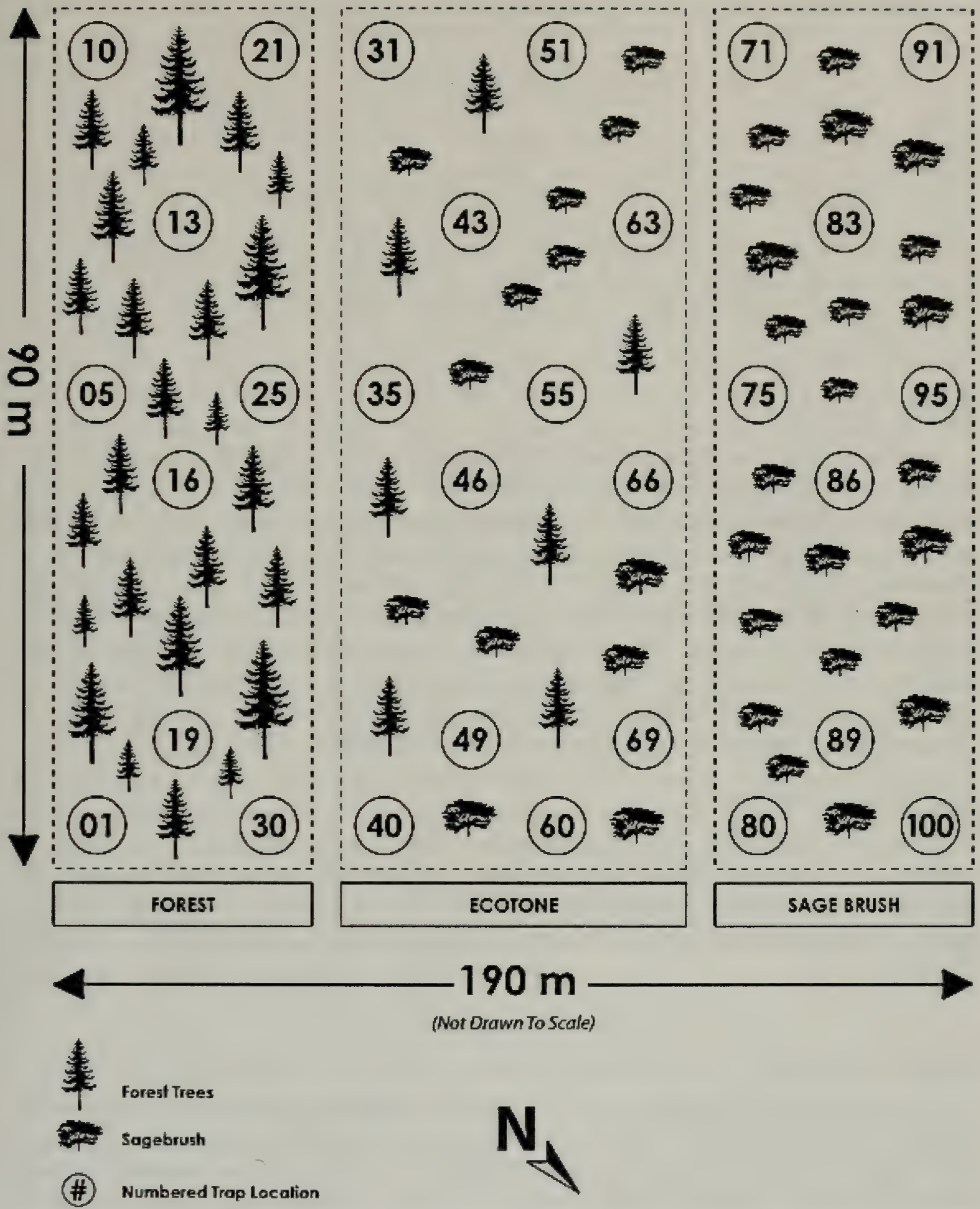
Artificial feeding stations (similar to those described by Brown 1971) were utilized to observe possible interspecific and intraspecific interactions. Feeding stations consisted of a small food pile located in an area where both species were known to occur and that had an unobstructed view. Dried fruits, raw almonds, raw sunflower seeds, and uncooked oats were used to attract visitors to the feeding station. A total of four feeding stations was established, one each in the coniferous forest and sagebrush scrub and two in the ecotone.

Observations were conducted from observation areas approximately 10 m from the feeding stations. A Winchester spotting scope (15–45 × 50 mm), Bushnell 10 × 25 mm compact binoculars, Olympus handheld micro-cassette recorder, and Olympus Camedia C-750 digital camera were used to assist in the collection of data.

A Sony Digital 8 Camcorder was used to record ninety-minute spans of continuous real time data of chipmunk interactions while at the feeding station. These included feeding, grooming, social, and aggressive behaviors. All observed behaviors and interactions, both interspecific and intraspecific, were recorded along with the respective times and dates.

An aggressive interaction was defined as an event between two or more individuals of the same or different species that included biting, chasing, vocalization directed at a specific individual, or fighting. An individual was deemed a winner of the aggressive interaction if that individual was successful in defending its position. The individual who abandoned the position was deemed the loser of the event. An event where an individual made a clear and distinct attempt to travel towards a feeding station but was halted by the presence of another individual or group and then clearly changed course was considered an avoidance interaction.

Although the distance (10 m) between the observation areas and the feeding stations was relatively close this was the maximum distance that allowed the two species to be easily distinguished. To verify that this distance did not have an effect on the subjects, the number of visits to the feeding station while under human observation ($n = 39$) were


90 m
10
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49
69
40
60
71
91
83
75
95
86
89
80
100
FOREST
ECOTONE
SAGE BRUSH
190 m
(Not Drawn To Scale)
Forest Trees
Sagebrush
Numbered Trap Location
N

Fig. 1. Schematic map of the study area showing selected trapping stations, approximate distribution of major vegetation, and the layout of "forest", "ecotone", and "sagebrush scrub" habitats (map not drawn to scale).

compared to the number of visits to the feeding station under video monitoring (n = 31). There was no significant difference between the two ($X^2 = 0.914$, 1 df, $p \geq 0.339$).

All fieldwork and handling of animals was conducted under Animal Protocol #793 approved by the San Jose State University Institutional Animal Care and Use Committee and California Department of Fish and Game scientific collecting permit (#SC-007372) following the guidelines of the American Society of Mammalogists (Animal Care and Use

Table 1. Chi Square Goodness of Fit for chipmunk habitat utilization.

	N. amoenus Captured	*N. minimus* Captured	df	X^2	P
Forest	84	10	1	58.24	< 0.001
Ecotone	28	25	1	0.17	> 0.05
Sagebrush	5	27	1	15.12	< 0.001

Committee 1998). Six voucher specimens (three of each species) were preserved as vouchers and deposited in the Bird and Mammal collections at San Jose State University (*N. minimus* #'s 3524-3526 and *N. amoenus* #'s 3527-3529).

Results

Habitat Utilization

A total of 1300 trap-days yielded 179 captures (Table 1). Both *N. amoenus* and *N. minimus* were abundant in the study area with 65% of captures consisting of *N. amoenus* and 35% of captures consisting of *N. minimus*. Males were more readily captured than females and 52% of the sample was recaptures. Trapping effort was most successful in the forest area, Traps 1–30 (Figure 1), with 52% of the captures. The ecotone and sagebrush areas accounted for 30% and 18% of the captures, respectively. In the forest area, *N. amoenus* was the most abundant, comprising 89% of the sample (Table 1). There was no significant difference (Table 1) in the distribution of these two species in the ecotone area (Traps 31–70, Figure 1). In the sagebrush area (Traps 71–100, Figure 1), *N. minimus* was the species most caught and consisted of 84% of the captures (Table 1).

Behavioral Interactions

A total of 80 interspecific interactions between *N. amoenus* and *N. minimus* was recorded at the artificial feeding stations (Table 2). Of the 80 total interactions, 65% were aggressive with *N. amoenus* clearly the physical aggressor, while the remaining 35% were avoidance behaviors taken by *N. minimus* in response to the aggression by *N. amoenus* (Table 2).

Discussion

Habitat Utilization

It is evident that, at this site, *N. amoenus* and *N. minimus* occupy distinct habitat types (Table 1). In the conifer dominated areas the most abundant species was *N. amoenus*, with a small number of *N. minimus*. In the arid sagebrush areas, *N. minimus* was the most abundant. In the ecotonal area there was no significant difference in the numbers of *N. amoenus* and *N. minimus* (Table 1). These data support the conclusion that *N. amoenus* appears to be excluding *N. minimus* from the forest, as was reported by Sheppard (1971). Chappell (1978) suggests that it is the ability of *N. minimus* to tolerate a higher heat load and lower water loss that allows it to live in less than optimal conditions. Therefore, the

Table 2. Chi Square Test for Independence for chipmunk interspecific interactions.

	N. amoenus	*N. minimus*	df	X^2	P
Aggressive Interactions Won	52	0	1	75.69	< 0.001
Interactions Avoided	0	28			

conditions of the arid sagebrush may be excluding *N. amoenus* or may be helping to restrict *N. minimus*.

Behavioral Interactions

The artificial feeding stations were highly successful in attracting both species at the same times during the day. The most successful station was located in an ecotonal area easily accessible to both species. Once both species began utilizing the feeding stations a clear hierarchy was established both intra- and interspecifically. *Neotamias amoenus* proved to be the more aggressive and social species of the two (Table 2).

Many intraspecific aggressive interactions were observed between *N. amoenus* individuals at the feeding stations. There were times when some individuals would feed in a group and other times where a dominant *N. amoenus* would chase off conspecifics and feed alone. *Neotamias amoenus* was frequently observed traveling in groups of two to four individuals. Other animals would visit the feeding stations from time to time including golden mantle ground squirrels (*Spermophilus lateralis*) and Steller's jay (*Cyanocitta stelleri*). These animals would either share the station with chipmunks or chase away a single or pair of chipmunks. However, if there was a group of at least three *N. amoenus*, then *N. amoenus* would be successful in chasing away other animals taking control of the feeding station. This observation demonstrates the advantage to *N. amoenus* of not only being aggressive (Chappell 1978; Meredith 1976; Sheppard 1971) but, also, to travel in social groups.

Neotamias minimus visited the feeding stations far less often than *N. amoenus*. *Neotamias minimus* appears to be a solitary species and was never observed approaching a feeding station in groups. Only when there were no other animals within close proximity (at least 5 m) of the feeding station did an individual *N. minimus* approach the station. This species also showed no obvious signs of intra- or interspecific aggression throughout the study. Avoidance, the act of an individual changing course or direction in response to the presence of an individual of the opposing species (Sheppard 1971), was a commonly observed behavior in *N. minimus* and accounted for 35% of the total behavioral observations (Table 2). In every avoidance encounter recorded, *N. minimus* would change course or direction apparently to avoid *N. amoenus*.

Conclusion

From data presented in this study it appears that *N. amoenus* excludes *N. minimus* from the forest area through the competitive exclusion mechanisms of social dominance and aggressive interactions. Although it is suggested in this study and by previous studies that both species are capable of existing in all three habitats (forest, ecotone, sagebrush scrub), *N. amoenus* tends to primarily occupy the forest while *N. minimus* occupies mostly sagebrush scrub. Observations in this study confirm that *N. amoenus* is the more aggressive species and that it is a more social animal than *N. minimus*. These two traits seem to confer a competitive advantage to *N. amoenus* allowing it to occupy its preferred habitat and exclude *N. minimus*. *Neotamias minimus* was not observed to have won any aggressive bouts with *N. amoenus* and appears to lack the social structure seen in *N. amoenus*. *Neotamias minimus* was always observed traveling and feeding alone, whereas, *N. amoenus* was observed, at times, to travel and feed in small social groups. These important life history aspects, aggression by *N. amoenus* and avoidance by *N. minimus,* have led, most likely, to the current habitat partitioning between these two species observed in this study.

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Literature Cited

Animal Care and Use Committee. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. J. Mamm., 79:1416–1431.

Armstrong, R.A. and R. McGehee. 1980. Competitive exclusion. Amer. Nat., 115:151–170.

Bergstrom, B.J. 1992. Parapatry and encounter competition between chipmunk (*Tamias*) species and the hypothesized role of parasitism. Amer. Midl. Nat., 128:168–179.

Brown, J.H. 1971. Mechanisms of competitive exclusion between two species of chipmunks. Ecology, 52: 305–311.

Chappell, M.A. 1978. Behavioral factors in the altitudinal zonation of chipmunks (*Eutamias*). Ecology, 59: 565–579.

Connell, J.H. 1961. The influence of interspecific competition and other factors on he distribution of the barnacle *Chthamalus stellatus*. Ecology, 42:710–723.

Hall, E.R. 1981. The Mammals of North America. Second edition. John Wiley and Sons, New York. 1181 pp.

Heller, H.G. 1971. Altitudinal zonation of chipmunks (*Eutamias*): Interspecific aggression. Ecology, 52: 312–319.

Kays, R.W. and D.W. Wilson. 2002. Mammals of North America. First edition. Princeton University Press, Princeton, New Jersey. 240 pp.

Meredith, D.H. 1976. Habitat selection by two parapatric species of chipmunks (*Eutamias*). Can. Jour. Zool., 54:536–543.

———. 1977. Interspecific agonism in two parapatric species of chipmunks (*Eutamias*). Ecology, 58: 423–430.

Morse, D.H. 1974. Niche breadth as a function of social dominance. Amer. Nat., 108:818–830.

Patterson, B.D. 1980. Morphological shifts of some isolated populations of *Eutamias* (*Rodentia: Sciuridae*) in different congeneric assemblages. Evolution, 35:53–66.

Savage, J.M. 1958. The concept of ecological niche, with reference to the theory of natural coexistence. Evolution, 12:111–121.

Sheppard, D.H. 1971. Competition between two chipmunk species (*Eutamias*). Ecology, 52:320–329.

Sutton, D.A. 1992. *Tamias amoenus*. Mamm. Sp., 390:1–8.

Verts, B.J. and L.N. Carraway. 2001. *Tamias minimus*. Mamm. Sp., 653:1–10.

Whittaker, R.H., S.A. Levin, and R.B. Root. 1973. Niche, habitat, and ecotope. Amer. Nat., 107:321–338.

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Research Note

Effects of Marine Mammals on the Sport Fishery in Santa Monica Bay, California

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Marine mammal-sport fishery interactions in Southern California waters are often observed but far less studied than marine mammal interactions with commercial fisheries (Hanan and Read 1989, Beeson and Hanan 1996, NMFS 1997). Older studies (Fiscus and Baines 1968, Miller et al. 1983) show that sea lions rarely interact with fishing activities in and near Santa Monica Bay while, in later investigations, California sea lions (*Zalophus californianus*) are reported to negatively affect sport fishing (Beeson and Hanan 1996). Previous to our study, no information was reported on interactions between fishermen and other species of marine mammals, except for Miller et al. (1983).

The abundance of marine mammals and sport fishermen makes Santa Monica Bay an excellent area to further investigate marine mammal-sport fishery interactions, to compare results with previous findings, and to provide information for future conservation and management decisions linked with the creation of a Marine Protected Area in Santa Monica Bay. The most common marine mammals known to inhabit and feed in the bay year-round include the California sea lion, the bottlenose dolphin (*Tursiops truncatus*), the short-beaked common dolphin (*Delphinus delphis*) and the long-beaked common dolphin (*D. capensis*) (Bearzi 2005a).

A survey of sport fishermen was conducted during 1998–1999 to gather general information on the type of interactions existing between marine mammals and fishermen activities and how marine mammals affect sport fishery in Santa Monica Bay.

Of 90 interviewed sport fishermen, 30 were selected for the survey in Marina del Rey and Redondo Beach harbors during February–June 2000. The fishermen selected were required to have fished year-round and to have made at least 20 fishing trips per year in Santa Monica Bay (Point Vicente 33° 45′ N 118 24′ W to Point Dume 33° 59′ N 118 48′ W, up to 20 km offshore). Further, the fishermen were chosen from both charter boats ($n = 18$) and private vessels ($n = 12$); this was different from previous investigations where those interviewed were exclusively on charter boats (Miller et al. 1983, Beeson and Hanan 1996).

Information about Sport Fishermen and Their Catches - Of the selected fishermen, 87% stated they spent 1–3 days per month fishing in the bay and 80% preferred fishing during the summer months (June–August). Most (67%) fished less than 10 km from shore, of which 43% were within 1–5 km and only one fisherman at less than 1 km from shore. In 1998, 38% of the fishermen reported catching mostly "bass" (the term bass is generally used by local fishermen to include any fish species similar to a rockfish) and 36% reported catching mostly yellowtail, *Seriola lalandi*. In 1999, 47% of the fishermen reported catching "bass" most abundantly while only 13% reported catching yellowtail.

Interactions with Marine Mammals - All the fishermen observed dolphins in 1998 and 1999. Virtually all (97%) stated that dolphins – generally recognized as "common dolphins" - never interfered with their fishing operations; one fisherman reported one instance in which a dolphin took a single fish off a fishing line. None observed dolphins feeding behind their vessels although 17% occasionally observed dolphins traveling nearby. California sea lions, however, were reported by 93% to commonly cause gear damage and/or fish depredation while foraging opportunistically around their boats.

Conclusions - Dolphins rarely interacted with fishing activities while California sea lions were reported to negatively affect sport fishing (see also: Hanan and Read 1989, Beeson and Hanan 1996). Considering that older studies (Fiscus and Baines 1968, Miller et al. 1983) had not reported impacts with sport fishing activities in Santa Monica Bay and adjacent areas, an increasing trend of sea lion interactions over time is suggested. This growing interaction between sea lions and fishing activities may be due to the annual rate of increase in the sea lion population of about 5–6% per year since the mid-1970s in California (NMFS 1997; see also: Beeson and Hanan 1996, Carretta et al. 2006), and the concurrent increase in sport-fishing activities in the bay with over 5.5 million sport fishing trips made annually (http://www.nationalestuaries.org/publications.htm, Dotson and Charter 2003).

Although there is a large overlap in the diet of both common dolphin species and sea lions (Bearzi 2006) and these species are often found foraging together in Santa Monica Bay (Bearzi 2005a), these animals interact differently with sport-fishing activities. This difference may be due to slight differences in the prey caught by common dolphins and sea lions. While northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), Pacific whiting (*Merluccius productus*) and jack mackerel (*Trachurus symmetricus*) are the main prey of both sea lions and common dolphins, rockfish (*Sebastes* sp.) are consumed mainly by sea lions (Fitch and Brownell 1968, Lowry et al. 1990, Schwartz et al. 1992, Bonnell and Dailey 1993). Based on the interviewed sport fishermen of this study and other sources (e.g., rockfish combined; SCCWRP et al. 1994, Dotson and Charter 2003) rockfish are also amongst their most targeted species in the study area.

Bottlenose dolphins likely did not interfere with sport fishing activities because: 1) of differences in targeted fish species (for a summary of bottlenose dolphin prey see: Bearzi 2003), 2) their entire coastal population usually remains at less than 1 km from shore (Bearzi 2005b) and only one fisherman was recorded to fish at this distance from the coast, 3) the offshore population are usually more frequent outside the bay (Bearzi, pers. obs.)

California sea lions have been observed to follow dolphins, possibly taking advantage of the dolphins' echolocation abilities to find prey (Bearzi 2006). Similarly, sea lions may take advantage of sport fishing activities to facilitate their foraging success in the bay and also by taking fish off the fishermens' lines. Miller et al. (1983) stated that this sea lion behavior is likely learned because they believe that depredation was not recorded from 1950–1970.

The results of this study show the need to further investigate the interactions between California sea lions and sport-fishery in the bay. This data also provides preliminary information for making sound and balanced management decisions affecting the future of sport fishing activities and the high sea lion presence in the candidate Marine Protected Area of Santa Monica Bay.

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Literature Cited

Bearzi, M. 2003. Behavioral ecology of the marine mammals of Santa Monica Bay, California. Ph.D. dissertation, University of California, Los Angeles.

———. 2005a. Habitat partitioning by three species of dolphins in Santa Monica Bay, CA. Southern California Academy of Science Bulletin, 104(3): 113–124.

———. 2005b. Aspects of the ecology and behaviour of bottlenose dolphins (*Tursiops truncatus*) in Santa Monica Bay, California. Journal of Cetacean Research and Management, 7:75–83.

———. 2006. California sea lions use dolphins to locate food. Journal of Mammalogy, 87(3): 606–617.

Beeson, M.J. and D.A. Hanan. 1996. An evaluation of pinniped-fishery interactions in California. Report to the Pacific States Marine Fisheries Commission, 46 p.

Bonnell, M.L. and M.D. Dailey. 1993. Marine mammals. Pp. 604–681 *in* M.D. Dailey, D.J. Reish, and J.W. Anderson, eds. Ecology of the Southern California Bight. University of California Press, CA.

Carretta, J.V., K.A. Forney, M.M. Muto, J. Barlow, J. Baker, B. Hanson, and M.S. Lowry. 2006. U.S. Pacific Marine Mammal Stock Assessment: 2005. NOAA-TM-NMFS-SWFSC-388.

Dotson, R.C. and R.L. Charter. 2003. Trends in the Southern California sport fishery. CalCOFI, 44: 94–106.

Fiscus, C.H. and G.A. Baines. 1968. Food and feeding behavior of Stellar and California sea lions. Journal of Mammalogy, 47(2): 195–200.

Fitch, J.E. and R.L. Brownell. 1968. Fish otoliths in cetacean stomachs and their importance on interpreting food habits. Journal of the Fisheries Research Board of Canada, 25:2561–2574.

Hanan, D.A. and R.B. Read. 1989. California sea lion interaction and depredation rates with the commercial passenger fishing vessel near San Diego. CalCOFI, 30:122–126.

Lowry, M.S., C.W. Oliver, C. Macky, and J.B. Wexler. 1990. Food habits of California sea lions, *Zalophus californianus*, at San Clemente Island, California, 1981–86. Fishery Bulletin, U. S., 88:509–521.

Miller, D.J., M.J. Herder, and J.P. Scholl. 1983. California marine mammal-fishery interaction study, 1979–81. NMFS Southwest Fish. Cent., Admin. Rep. LJ8313C, 233 p.

National Marine Fisheries Service (NMFS). 1997. Investigation of Scientific Information on the Impacts of California Sea Lions and Pacific Harbor Seals on Salmonids and on the Coastal Ecosystems of Washington, Oregon, and California. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-28, 172 p.

Schwartz, M., A. Hohn, H. Bernard, S. Chivers, and K. Peliter. 1992. Stomach contents of beach cast cetaceans collected along the San Diego County coast of California, 1972–1991. Southwest Fisheries Science Center Administrative Report LJ-92-18.

Southern California Coastal Water Research Project (SCCWRP), and MBC Applied Environmental Sciences. 1994. Santa Monica Bay seafood consumption study. Prepared for Santa Monica bay Restoration Project, Monterey Park, CA.

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McWilliams, K. L. 1970. Insect mimicry. Academic Press, vii+326 pp.

Holmes, T. Jr., and S. Speak.1971.Reproductive biology of Myotis lucifugus. J. Mamm., 54:452–458.

Brattstrom, B. H.1969.The Condor in California. Pp. 369–382 in Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii+635 pp.

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Cover: Long-beaked common dolphin in Santa Monica Bay, CA. Photo by Maddalena Bearzi.